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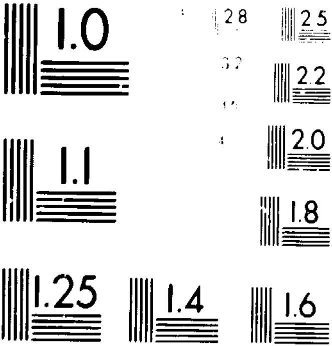

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UNITED NATIONS
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A FACTORY CONCEPT FOR INTEGRATED CASSAVA PROCESSING OPERATIONS*

US/INT/80/006

The cassava processing concept

Based on the work of D. R. Atkinson, D. J. Wholey, T. R. W. Jarman, and
J. Turnbull of P-E International Operations Ltd. and
Minster Agriculture Ltd., UK

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PREFACE

Although cassava in its various forms is a traditional food in many developing countries, a very large unutilized cassava potential still exists on a global level availing utilization by suitable processing industries to be established for the production of a variety of cassava products for domestic markets and exports.

In the light of the world food situation, requiring the further expansion of food supplies with regard to quality and quantity, cassava will have to find its due recognition as a source of food. A great variety of products can be produced that may be highly in demand of the market. Such products for example are starches, flours, syrups, glucose and last but not least food and feed grade leaf protein.

A pre-condition of appropriate cassava processing operations, however, is the industrial approach to the cassava utilization problem. The traditional way of small and village scale processing can hardly solve the cassava utilization problem. In order to really utilize cassava to an optimum extent with all the socio-economic implications involved, it will have to be made an industrial raw material by relevant preparations to make it suitable for factory scale processing. There will certainly always be village scale preparations and/or direct consumption of cassava and its products but such traditional activities cannot replace industrial operations or improve food supplies in general.

Modern scale industrial cassava processing operations for the production of uniform quality and low-cost products that are in demand of the market will have to take the lead in the overall cassava processing sector. Such modern cassava processing factory concepts will have to be based on the production of a variety of cassava products in order to achieve the required economic production flexibility and to be able to adjust its production to prevailing market demands. Such factory concepts will further have to be based on the principle of the optimum utilization of the rather perishable cassava raw material and might, therefore, have to establish close links with organized agricultural cassava production scheme.

An attempt has been made to elaborate such a modern integrated cassava processing factory concept which UNIDO is glad to present in this document. The model concept may find the attention of the authorities of cassava producing developing countries for their industrialization policy considerations. The model concept may, however, also find the attention of industrialists, investors and all engaged and interested in the setting-up and operation of integrated cassava processing factories for the production of quality food products.

1. INTRODUCTION

The aim of the project is to elaborate and evaluate the concept of setting up a factory or factories to make the range of products which can be derived from cassava in any country whose climate will support its growth.

This necessitates study of the agronomy of the cassava crop and of the procurement system needed to ensure an adequate supply of raw material; research into the markets for products derivable from cassava; the definition of appropriate technology and the outline design of a typical factory; and the evaluation of the concept, both financially and economically.

UNIDO chose Zambia as the country in which the concept was to be tested, and from this study there has emerged a specific project proposal for Zambia, which is described in document number UNIDO/IO/R.51

This report, however, stands as a document on its own, and where the findings of the Zambian study are needed to illustrate the elaboration of the global concept, they are repeated here.

The first stage of the study, a fact-finding tour of Zambia, was carried out in November and December by a team including:

- D. R. Atkinson (P-EIO), Team Leader and Economist
- D. J. Wholey (MAL), Cassava Specialist
- F. R. W. Jarman (MAL), Cassava Processing Specialist
- J. Turnbull (MAL), Farm Management Specialist.

The team was enlarged during the preparation of the interim and draft final reports in January - May 1982 by our P-EIO consultants: K. B. Freemand and R. W. Waghorn, project engineers, and C. J. S. Baker and A. H. Catterall, financial analysts. Support was also provided by P-EIO's Marketing Research Department.

The interim report was sent to UNIDO, Vienna on 27 January 1982 and reviewed with Mr. H. Koenig, Senior Industrial Development Officer, Agro-Industries Branch, on 22 March 1982.

The draft final report was sent to UNIDO, Vienna on 5 July and accepted on 13 July 1982.

The team wishes to thank the UNIDO staff in Vienna, the UNDP staff in Lusaka and the many organisations and persons who have helped in this project, for their outstanding co-operation.

The theme of the conceptual study may be described as "If cassava processing is to succeed, the following conditions are necessary", and individual countries' conditions can then be checked against these requirements. In the case of Zambia, the facts on agronomy, markets and locations are precisely established, and a project is positively recommended.

2. SUMMARY

Refer to

2.1 Versatility of Cassava

Chapter 4

All parts of the cassava plant have uses: tubers, as raw and cooked food (after de-toxification), and as a source of starch and derived glucose and dextrins; the leaf, as a source of protein; the stem, as a source of planting material, stockfeed and particle board.

2.2 Markets for Cassava and Derived Products

Chapter 4

These vary very widely: Thailand, for example, exports millions of tonnes of cassava pellets to the EEC and produces 400,000 tonnes of starch; at the other extreme, the proposed factory in Zambia will produce 3-4000 tonnes of starch.

In Zambia, where cassava is a subsistence crop, there is a latent demand for cassava flour, based on marketed chips, and a potential industrial demand for nationally produced starch, glucose and dextrins in place of imports. We foresee no export potential.

2.3 Agronomic Considerations

Chapter 5

Of world output of cassava, 38% is grown in Africa, 36% in Asia and 25% in S. America. Table 4

Provisional FAO figures of yields per hectare show that these are substantially higher in Asia and S America than in most African countries. Zambia has a particularly low yield. Table 5

The main influences on growth are temperature (growth ceases at $10^{o}C$) and rainfall (1000 - 1500 mm are needed for an annual crop). Soil type must not be saline or sodic; otherwise cassava is tolerant of soil as long as it is not badly drained. 5.3

		Refer to
	African cassava production is particularly affected by virus and bacterial diseases, and pests are encouraged in those countries with long dry seasons.	Appendix 7
	Improved varieties are increasingly available, with resistance to specific pests and diseases.	5.4
	Fertiliser recommendations vary with soil and climate; in general, potassium levels are critical to the starch content of cassava.	5.5
	It is essential to grow break crops to avoid build-ups of pests and diseases in cassava.	5.6
2.4	**Procurement of Cassava**	Chapter 6
	The processing factory must have a consistently available supply of raw material of the right quality, at a price enabling economic operation.	6.1
	The factory can achieve control over availability and quality by having its own plantation, but the capital costs of machinery and the costs of hired labour will make this uneconomic in many cases.	6.2
	Cassava roots deteriorate after 24 hours. To avoid the formidable problem of collecting roots over a significant distance it may be advisable to use chips, sun-dried by the farmer. These will not yield the same quality or quantity of starch as do fresh roots, but they do not deteriorate quickly and are adequate for some starches and for all glucose and dextrins. Roots, bought close to the factory, can be used for high quality starch.	6.3
	Farmers should be paid a higher price for roots, relative to chips, than a comparison of their starch content warrants.	6.4
	Chips must be thoroughly dried, using sun and wind to best advantage. They should be sliced 5 mm thick and 50-80mm long.	6.5 Appendix 5

Refer to

2.5 Considerations of Process Design — Chapter 7

Water used in a starch factory must be of potable quality. Modern processes re-use some water, but consumption is still high: typically, 4300 litres/tonne of starch produced. A dry process needs further research, but it may prove feasible to produce starch of limited use in this way in the future. — 7.2

Effluent from the wet starch process will contain some sugars, which must be treated by a ditch and weir system or a treatment plant. — 7.3

Factories should be as simple as possible and designed with location and operators' skills in mind. — 7.4

It may be possible to incorporate leaf protein processing into cassava plants in the future. This needs more study and perhaps a pilot production and marketing trial. — 7.5

2.6 Outline of Factory — Chapter 8

The processes of converting fresh roots to starch, chips to starch, chips to glucose, and starch to dextrin are described in detail, together with a note on the possibility of converting glucose to potable alcohol.

Layouts of the Zambia factory are shown in Appendices 8 and 9, and list of plant required and of possible suppliers in Appendices 10 and 11. — Appendix 8, Appendix 9, Appendix 10, Appendix 11

Recommendations are made on effluent disposal. — 8.3

2.7 Financial Evaluation — Chapter 9

The starch, glucose and dextrins factory proposed for Zambia will require a capital investment of K3,800 thousand, of which 52.6% will be loan capital and 47.4% equity. An overdraft equal to approximately half the working capital will be needed initially. — Appendix 12; Report 9

	Refer to
Profit after tax (payable only from Year 6 onwards) is calculated to rise from K129,000 in year 1 of production to K504,000 in year 6.	Report 8
The overdraft should be repaid after 2½ years of production and all loan capital after 5½ years. A small dividend can be paid to equity shareholders until year 5; thereafter a dividend of 15-20% should be payable.	Reports 9&10
The IRR on the project is 13.64%.	Report 12
Sensitivity analysis shows that the project is more sensitive to price changes then to volume changes.	Report 13
An analysis of a starch-only factory shows an IRR of only 8.36%.	Appendix 13

3. PROJECT BACKGROUND AND HISTORY

Before the study began Mr Koenig of UNIDO explained its background as follows:

- world interest in cassava is stagnant, if not declining. An imaginative, practical concept is needed to revive that interest.

- many tropical countries grow cassava, but the supply and markets are not organised. Processing plants have been set up in several parts of the world, but they have usually been single-product plants, subject to variations in demand for those single products. Supplies of cassava have been intermittent. Thus factories have shut from time to time because of lack of demand or lack of supply. Farmers, wanting to sell but finding the factory shut, abandon cassava as a cash crop and use it only for subsistence.

- a multi-product cassava processing factory may be able to overcome these difficulties, by altering the mix of derived products according to the state of market demand and thus offering a stable outlet for cassava roots or chips as a cash crop.

- a conceptual study is therefore needed, embracing the markets for products derived from cassava; the agronomic requirements of the crop; the procurement system needed to induce an adequate supply; processing technology; and the financial and economic feasibility of the scheme.

The conceptual study should be made on the basis of markets and supplies being free from artificial constraints or encouragements. The results would, of course, have to be adapted to take account of such constraints or encouragements in any particular country.

4. MARKET CONSIDERATIONS

4.1 The Range of Markets

Given that it is agronomically feasible to grow cassava in a country the starting point of an evaluation of an integrated cassava processing factory concept must be a study of the demand for the crop and the products which can be manufactured from it.

The study of demand in Zambia is briefly described below, and presented more fully in Volume 2, Chapter 8. In summary, Zambia has a small population; virtually no organised market for cassava at present; a potential national demand for marketed cassava in Nshima, bread and beer; a potential national demand for cassava-based starch, glucose and dextrins, based on import substitution; and no export potential, because of great transport distances and a small, high-cost scale of potential output.

At the other end of the scale, Thailand has developed a huge cassava industry, exporting millions of tonnes of cassava pellets to the EEC for animal feed, and processing cassava roots to produce about 400,000 tonnes of starch a year. (Compared to the 4,000 tonnes a year envisaged in Zambia after 5-6 years of the factory's operation).

Clearly, there is a wide range of circumstances in cassava-producing countries, each of which needs individual study. In this volume 1, outlining the integrated cassava processing factory concept, it seems useful to list the various uses to which cassava can be put and to describe the findings of the market study in Zambia.

4.2 Uses of Cassava

As shown in Table 1, cassava is one of the most versatile of plants. After de-toxification of its tubers by soaking and peeling, they can be eaten raw, if young enough; or as is more common, boiled or baked; or dried; or fermented; and mixed with protein relishes of fish, or meat, or leaf protein.

The cassava leaf is a valuable source of protein (see Chapter 7 below) and the stalk, apart from providing cuttings for plant propagation, can be ground into a constituent of animal feed or, if very woody, into a constituent of particle board.

Cassava meal or flour is the basic ingredient of the main staple dish in several parts of Africa, and a useful thickener for many products.

Starches, derivable from cassava, have a wide range of uses, from infant foods to oil well drilling, as illustrated in the table. Their use as a basic material for glucose and dextrins is particularly important.

In evaluating the feasibility of setting up a cassava processing factory it will be necessary to consider, in the content of the individual country studied:

- its present and potential consumption of cassava and each of the products derivable from the plant

- the quantity and cost of imports of the derivable products
- the potential for export of the derivable products.

TABLE 1 - USES OF CASSAVA

Root

Raw (peeled young root or aipim)
Cooked, boiled, or baked for table use (95% of production)
Shredded and mixed with coconut, oil, peanuts, greens, spices
Dried (called kokonte, gaplek, etc., in Africa)
Grated and fermented, added palm oil, fried (called gari in Africa)
Fried slices (French frying, etc)
Residue (fibre or bagasse) from starch extractives
Chipped or sliced for livestock (dairy and beef cattle, goats, pigs, chickens)
Root peel livestock feed
Broken roots
Pellets
Juice (tucupay or cassaripo)

Leaf

Used as a vegetable
Cooked
Soup ingredient
Fortified food supplement
Livestock feed
Ensilage
Dried - Used in animal feed fortification
Leaf meal (feed concentrates)

Stalk (stems)

Cuttings for plant propagation
Grafting material for increased yields
Mixes with leaves as ruminant feed
Dried (used in animal feed concentrate)
Particle board

Chips (raspa or gaplek)

Ground into meal or flour
Extracted for starch
Fermented (fufu) - meat, oil, vegetables, spices and water added animal feeds
Pellets

Meal or Flour

Bakeries, pastries, alimentary pastas (macaroni)
Boiled in soups, sauces, gravies, etc.
Bread extender
Porridge (gruel)
Fortified flour (with wheat, soya, peanut, vitamins, etc)
Improved bread flour (with added calcium stearyl lactate as a conditioner)
Protein enriched flour (fish protein concentrate, soyabean isolate, caseim,etc)
Selected amino acid enriched flour (lysine, tryptophane, methionine, etc)
Fermented (Eba)
Glues
Adhesives

Starch

Baked goods
Desserts - puddings, pie fillings (sago)
Infant foods
Confections (moulding of cast sweets)
Thickening agents (synthetic jellies)
Bodying agents (caramels)
Dusting agents (chewing gum)
Fermented beverages (beer)
Textile sizing and strengthening
Laundry starch
Paper sizing and bonding
Gums (envelopes, postage stamps, gummed tapes)
Dextrins (bonding pigment to paper; preventing glass checking)
Adhesives (cardboard, plywood, and veneer)
Glues and pastes
Blended with peanut flour, nonfat milk solids, vitamins
Enriched with LPC, soy, corn, rice (pasta)
Alcohol
Acetone
Glucose
Oil well drilling

Modified Starches

Pre-cooked soluble starches - "instant" puddings
Thin - boiling starches (confectionery manufacture)
Oxidised starches
Improved starches (ex: added glyceryl monostearate as a binding agent).

Source: Minster Agriculture Limited

4.3 The Market in Zambia

Cassava is almost entirely a subsistence crop in Zambia, grown in the remoter Provinces whose agronomic conditions do not favour the cultivation of maize, the main national staple crop. Cassava is not one of the crops bought by the state agricultural marketing system (Namboard) and has no producer price.

We found a significant latent demand among urban immigrants for cassava flour for use in Nshima, the staple dish in Zambia. Based on this consumer preference, cassava flour can be sold at a premium over maize.

There is a potential demand for cassava flour in bread-making and brewing, as a partial substitute for imported wheat and malted barley.

Starch, glucose and dextrins are all imported into Zambia, and users in the growing foodstuffs, textile and paper industries would welcome a national supplier, provided their quality requirements were met. They would be willing to pay a premium over current import prices to avoid delays and difficulties caused by having to apply for foreign exchange.

The results of the market survey are shown in Table 2, followed by the projection of the market and of estimated factory sales up to 1991 in Table 3.

TABLE 2

Estimated potential for marketed cassava products in Zambia in 1981.

Product	Application	Present Potential (Tonnes/year)	Present Delivered Price + 10% (a) (K/tonne)	Reason for using cassava
Starch	Textiles	300	900	Import Replacement
	Food - biscuits, Blancmanges, Puddings,etc.	500 +	850	Import Replacement
Glucose	Food - biscuits, Puddings,etc.	1,400	1,050	Import Replacement
	Pharmaceuticals	30	1,200	Import Replacement
Dextrins	Glue for paper	150	1,800	Import Replacement
	Pharmaceuticals	5	1,800	Import Replacement
	TOTAL ABOVE	2,400 approx		
			Estimated Acceptable Price	
Cassava Flour	Nshima	40 - 45,000	Breakfast Meal + 7% (= roller + 35%	(i) Urban immigrant demand (ii) Quality improvement
	Blends with wheat flour	7-8,000(10%)	Roller meal price	(i) Replace imported wheat (ii) Release maize for other uses
	Chibuku & mosi beer	3,000 (10%)	Roller meal price	Release maize for other uses
	Stockfeed	12,500 (10%)	Roller meal price less 10%	Release maize but added protein required
	Potable alcohol (liquor blending)	litres 750,000	55n/litre	Import Replacement

(a) Users of starch and derived products, now imported, would be willing to pay at least a 10% premium for local supplies.

Table 3 - Estimated demand in Zambia for starch, glucose, and dextrins

Year	Volume change from previous Year (%)	Annual demand (values at 1981 prices (a)) Starch Tonnes	Starch K'000	Glucose Tonnes	Glucose K'000	Dextrins Tonnes	Dextrins K'000	Total K'000
1981	10	800	640	1430	1573	155	263	2475
1982	10	880	704	1575	1733	170	289	2725
1983	9	960	768	1700	1870	185	315	2950
1984	8	1035	828	1835	2020	200	340	3190
1985	7	1110	888	1960	2155	215	365	3215
1986	6	1175	940	2075	2283	230	390	3615
1987	5	1235	988	2180	2400	240	405	3795
1988	5	1300	1040	2290	2520	250	425	3985
1989	5	1365	1092	2400	2640	265	450	4180
1990	5	1435	1148	2520	2770	280	475	4395
1991	5	1510	1208	2650	2915	290	495	4620

(a) 1981 import prices + 10% premium less K100/tonne for delivery. (Net price for starch, K800/tonne; glucose, K1100/tonne; dextrins, K1700/tonnes).

5. AGRONOMIC REQUIREMENTS OF THE CASSAVA CROP

5.1 Background Information on Cassava

Cassava is the name used in the English speaking regions of Africa, the Caribbean and Australia to describe the plant refered to by botanists as Manihot esculenta (Crantz). The crop is also known as 'tapioca' in India and anglophone South East Asia, 'manioc' in French, 'yuca' in Spanish and 'mandioca' in Portuguese. Local names for the crop defy collation.

The plant is a member of the family 'Euphorbiaceae and is indigenous to tropical America, although it is currently grown in most tropical and many sub-tropical countries of the world. The plant is a short-lived perennial shrub with enlarged starch-rich roots. There are probably thousands of cultivars in existence which range in height from 1m to 5m, and vary from unbranched to heavily branched with stems green, brown, grey to light grey in colour. The leaves vary from small simple or three lobed in seedlings and young plants to large palmate leaves with nine to eleven lobes during the period of maximum growth rate. Fruit usually forms when the plant is in excess of one year old, especially in areas with short rainy season where the crop is usually grown as a biennial, over two rainy seasons. The fruit is a three-seeded capsule which opens explosively to disperse the seeds.

The roots of cassava develop from the stem cuttings during the second and third weeks after planting. Under good conditions nine or more fibrous roots become root-tubers during the second and third months of growth by a process of secondary thickening and starch deposition. The diameter of root-tubers increases with age until maturity which varies with variety but normally occurs after 5-15 months of growing conditions. Both the dry matter and starch content of root-tubers increase becoming fibrous and in some cases hollow. An advantage that the cassava crop offers the farmer is the lack of a fixed harvest date allowing great operational flexibility and enabling the farmer to store the crop in the ground.

The root-tubers form the primary product of the cassava crop. The usual size is 25-40cm in length and 5-15cm in diameter. The thickness of the peel and the ease with which it can be removed from the flesh of the root is a varietal characteristic. Peeling losses can vary between 10-20% of the fresh root.

At the core of the root-tuber there is a concentration of xylem vessels which become lignified with age. In over-mature roots these lignified vessels render the roots undesirably fibrous and are removed in some hand processes.

The cassava plant contains toxic principles which release hydrocyanic acid (HCN) under certain conditions. The cyanogenic glycocides linamarin and lotaustralin are distributed throughout the cassava plant, but the concentration varies greatly between varieties and also with climatic, edaphic and cultural conditions. Toxicity of cassava and its products is associated primarily with free HCN that is formed when the cyanogenic glycocides have been hydrolysed. This is effected by a hydrolytic enzyme Linamarase which is present in all the plant tissue together with the cyanogenic glycocides.

In active healthy tissue of the growing plant the enzyme and glycocide substrate do not come into contact, however on mechanical damage, eg after harvesting, contact occurs and hydrolysis takes place releasing HCN.

It is well established that HCN itself is one of the most powerful mammalian poisons known, large doses causing acute poisoning usually resulting in death. The lethal dose of HCN for an adult male is reported to be 50-60mg. A guide to acute toxicity is as follows:

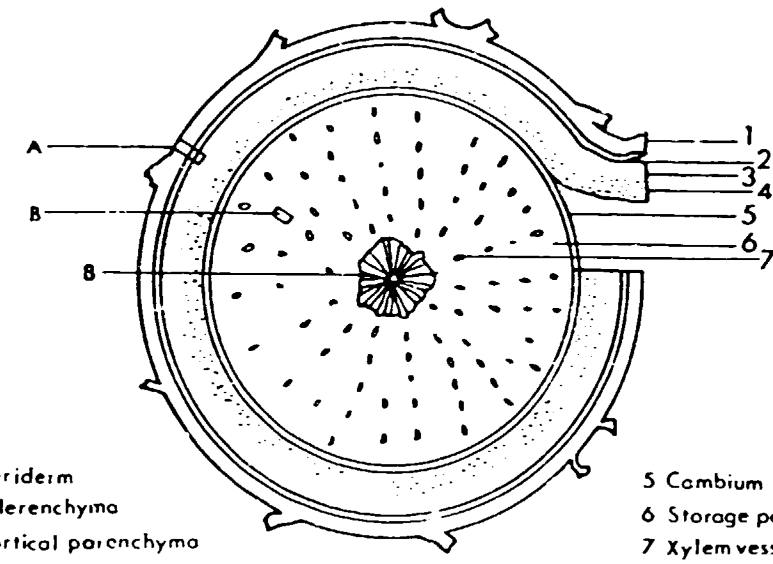
Innocuous	:	Less than 50mg HCN per kg of fresh peeled tuber (FPT)
Moderately poisonous	:	50-100mg HCN per kg of FPT
Dangerously Poisonous	:	Over 100mg HCN per kg of FPT

The habitual ingestion of small quantities of HCN, too small to produce acute symptoms can result in chronic effects including malfunction of the thyroid resulting in goitre in serious cases, and atoxic neuropathy causing lesions of the skin, mucous membranes, nerves and spinal cord. Both conditions are caused by indirect effects of HCN entering the bloodstream via the alimentary tract.

The peel fraction of cassava root-tubers contains substantially higher concentrations of cynaogenic glycocides than the flesh. The ratio of glycocide in peel to flesh varies between 5 to 10 : 1. Traditional users appear to be aware of the danger as peeling is practised as a preliminary to cooking.

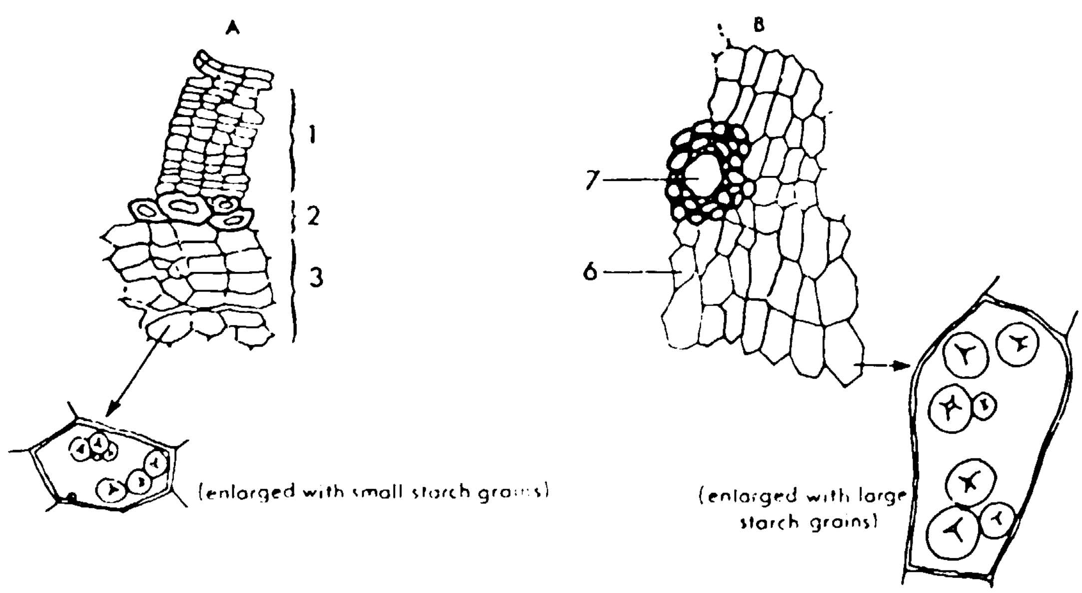
Previously, cassava variations with root-tubers containing small amounts of HCN were classified botanically as Manihot dulcis (or M. palmata) and those with large amounts of HCN, Manihot esculenta (M.utilissima). Currently all cassavas, sweet or bitter, are referred to as Manihot esculenta.

DIAGRAM OF TRANSVERSE SECTION OF CASSAVA STORAGE ROOT



peel
1 Periderm
2 Sclerenchyma
3 Cortical parenchyma
4 Phloem
(1 to 4 = peel)

5 Cambium
6 Storage parenchyma
7 Xylem vessel
8 Xylem vessels & fibres
flesh



SOURCE : Hunt, Wholey & Cock (1977)

5.2 Global Distribution of Cassava

Thought to have originated in the area of today's border between Brazil and Paraguay, cassava has been disseminated across the globe. In the western hemisphere the crop is grown from Northern Argentina to Florida State in the USA; from sea level to 4,000m in the Andes. Introduced into West Africa by the Portuguese, the crop has spread through the continent from the sub Sahel to South Africa. Today a high proportion of the continent's indigenous population depends on the crop for their diet, particularly in the coastal Western African countries. Although only reaching South East Asia some 150 years ago, the crop is a very important human food in Indonesia and South India and an important industrial crop in Thailand (its number one export crop in 1978). Recently the crop has been recognised as having potential in Northern Australia and Papua New Guinea - principally for ethanol production. To sum up, cassava is present in almost every tropical and sub-tropical country where the climate allows its growth. Table 4 shows the quantities of cassava produced in the various parts of the world as presented by the Food and Agriculture Organisation of the United Nations.

Table 4: Production of Cassava by Selected Countries in 1980 (a)

	Production Tonnes (x 1000)
Africa	
Zaire	12,500
Nigeria	11,000
Tanzania	4,600
Mozambique	2,800
Ghana	2,250
Angola	1,850
Madagascar	1,450
Uganda	1,300
Other African countries	9,023 (b)
TOTAL:	46,773
Asia	
Thailand	13,500
Indonesia	13,300
India	6,500
China	3,174
Vietnam	4,000
Philippines	1,900
Other countries	1,185
TOTAL:	43,559
South America	
Brazil	24,554
Colombia	2,640
Paraguay	1,950
Other countries	1,412
TOTAL:	30,556
Central American & Caribbean	
TOTAL:	1,024
Oceania	
TOTAL:	222
WORLD TOTAL:	122,134

Source: FAO Production Year Book 1980
(a) Figures mainly provisional
(b) of which Zambia, 177.

5.3 Growth Requirements

Temperature. Cassava growth is favoured by a warm moist climate with temperatures in the range 25-29°C. Temperatures lower than 25°C will reduce growth which, in general, ceases at 10°C. Research suggests that the base temperature for cassava germination is 13°C, and that emergence is retarded below 18°C. As it is the temperature of the growth medium that is the critical factor, the soil temperature in the 5-10cm zone should be used to delineate conditions favourable for establishment. Once the crop has emerged, both the soil temperature and air temperature play an important role. Whereas growth ceases at 10°C, the crop will survive lower temperatures and light frost but will defoliate under these conditions. Short duration severe frosts (ie below -3°C) kill exposed green tissue but growth is supported from woody tissue when temperatures rise. Longer term exposure to severe frost will kill all above-ground growth. Based on a 13°C base temperature for germination, Austalian research workers recommend planting to be done in areas with daily mean temperatures in excess of this figure. However more recent reports recommend 18°C as the low-level temperature boundary for cassava cultivation due to reduced percentage emergence and retarded early growth rate at below this temperature. As indicated above cassava is commercially grown at high altitude in the Andes, therefore it is to be expected that there exists a large varietal effect and some varieties may be tolerant to temperatures much lower than the 18°C suggested by the Australian cassava workers. Research at CIAT has proved that varieties tolerant of low temperatures exist. Temperatures in excess of 29°C are reported to affect yields adversely but little reliable information is available to confirm this figure.

Rainfall. Cassava thrives in areas receiving 1,000 - 1,500mm of rainfall, distributed evenly throughout the growing season. Physiological experiments indicate that different varieties have varying maturity patterns with some reaching a production peak after nine months of growing conditions whereas other varieties require in excess of twelve months. Therefore the practicability of producing cassava depends upon the interaction between variety and rainfall pattern. In the situation where only eight rainy months occur per year, a short season variety can be grown within the calendar year whereas a long season variety would not be feasible. Nevertheless cassava grows successfully in areas receiving as little as 500mm per annum, although the duration of the crop is extended in these areas, so that the crop takes up the moisture provided by two years' rain. This, coupled with the crop's ability to survive periods of drought within the growing season, renders the crop very useful to growers in regions with short rainy seasons and/or periods of uncertain rainfall. The effect of different rainfall patterns on cassava production is discussed in detail in Appendix 2.

Soil. Cassava will grow in a wide range of soil types from stiff marine clays through to almost pure sands. However the crop is intolerant of poorly drained soils. The crop is adapted to a wide range of soil pH and is especially tolerant to acid soils, producing good crops at pH 4.5. Nevertheless saline soils and sodic soils are not tolerated and result in stunted growth. Much of this wide adaptability of cassava is related to variety and care should be taken because all casssava varieties do not show this tolerance. Cassava is frequently the last crop grown in the shifting cultivation system practised in the forest zones of West and Central Africa and, as such, has earned the reputation for being well adapted to soils of low fertility. Recent research has identified a number of features that may be associated with cassava's special adaptation to poor soils including acid soils and soils with high free-aluminium content. Cassava appears able to maintain relative yields under low nitrogen, potassium and calcium conditions and capable of regulating its growth under low nutrient supply conditions. The crop can continue root bulking under severe lack of phosphorus which renders it extremely valuable for soils with very low phosphorus content. It has been suggested that the crop's ability to yield under apparently limiting phosphorus conditions is related to a soil mycorrhiza which forms a relationship with the roots of the cassava plant.

Experiments show that some cassava varieities respond to fertile soils, by producing stem and leaf out of proportion with root-tuber growth. The phenomenon appears to be related to variety as some 'more efficient' varieties appear to respond in terms of increased total (recoverable) biological yield with proportion in stem and leaves remaining constant to the proportion of tubers. Thus the 'harvest index' remains constant regardless of fertility. Cassava can tolerate sandy soil of extremely low fertility especially if the feeder roots can penetrate to 40-60cm and exploit the lower soil profile for nutrients (and moisture). Deep cultivation to facilitate root penetration frequently leads to increased yield.

On heavy soils where drainage is a problem and in areas where heavy rainfall is experienced causing short-duration waterlogging, cassava is usually grown on mounds or ridges to ensure that the root-tuber zone is relatively well aerated. Cassava does not thrive however in basin sites and chronically poor-drained areas, and growth will be retarded in spite of ridging.

Photoperiod. Experiments both in growth chambers and in the field indicate that the partitioning of dry matter between the roots and the above ground parts of the cassava plant is influenced by changes in day length. Thus harvest index is improved by growing the same variety closer to the equator, ie under short days. Colombian experiments indicate however that different varieties show different response to day length in terms of flowering response, therefore overall generalisations for all cassava varieties may be premature and further experimentation will be required to confirm this. Identification of day-neutral varieties, which do not respond to changes in photoperiod will pave the way to the availability of varieties with broad adaptation to changes in latitude.

Yields. National average yields as computed by FAO are presented in Table 5. They should be taken as rough approximations, since it is difficult to measure accurately the acreage of this crop, which is grown on scattered plots in most of the countries producing it. Moreover, in countries where the crop is harvested over more than one year - like Zambia - records of production are subject to wide margins of error.

Farm yields vary with location and are dependent on the interaction between variety, climate and soil with the effects of age at harvesting, disease, pests and management factors superimposed.

Table 5: National Average Yields of Cassava in 1980 (a)

	Tonnes/ha
Africa	
Zaire	6.65
Nigeria	9.17
Tanzania	4.89
Mozambique	4.67
Ghana	9.78
Angola	14.23
Madagascar	6.59
Uganda	3.42
Zambia	3.19
REGIONAL AVERAGE	6.41
Asia	
Thailand	13.30
Indonesia	9.37
India	17.57
China	13.06
Vietnam	8.33
Philippines	10.27
REGIONAL AVERAGE	11.34
South America	
Brazil	11.94
Colombia	10.95
Paraguay	10.83
REGIONAL AVERAGE	11.71
Central America and Caribbean	
REGIONAL AVERAGE	6.39
Oceania	
REGIONAL AVERAGE	11.07
WORLD AVERAGE	8.77

Source: FAO Production Year Book 1980
(a) Figures mainly provisional.

The world average is about $8\frac{3}{4}$ tonnes per hectare but the theoretical limit to yield has been calculated to be 90 tonnes per hectare per year. Experimental yields of 80 tonnes per hectare have been obtained from plants grown under near optimum conditions at CIAT. However the occurrence of debilitating diseases and devastating pests, together with poor agronomic practices and infertile soils, are responsible for relatively low farm yields in African major production areas. Virus and bacterial diseases particularly reduce root yields. Important pests in Africa include mealy bugs and green spider mite. These pests are currently spreading to new areas where severe yield reductions result. Pests and diseases, and means of combating them, are described in Appendix 7.

5.4 Varieties

There is a wide range of cassava varieties, and a global collection does not exist, although many countries have national collections and import improved varieties from elsewhere. Varieties vary in terms of adaptation to different climatic and soil conditions, and the performance of reputedly high yielding types introduced into a new area has frequently lead to disappointment.

As a result of research activities centred on the International Agricultural Research Centres in Africa (ZITA) and South America (CIAT), coupled with national research programmes, improved varieties are becoming increasingly available. These varieties have resistance to specific pests and diseases and should be selected in appropriate circumstances. From the point of view of the processor the content and quality of starch in the cassava roots is of paramount importance, and this factor is increasingly receiving attention from plant improvement scientists.

Yields quoted in published material may be misleading in that they reflect the yields attained from small plots sited on uniform land which received better than average attention. In many cases extended areas of the same variety may result in significantly lower yields than those obtained from small plots. Information on field-scale plantings should be sought before embarking on cassava production ventures. Where these are not available, the setting up of a pilot-scale production unit is to be encouraged to qualify the results from small-plot experiments.

Care in interpreting all results should be stressed, and where processing is the objective all yield figures should be converted to, and interpreted as:

- unit weight of starch, per unit area, per unit time.

5.5 Fertilisers

It is technically very difficult to sustain yields of any crop over extended time periods without supplementing the naturally occuring elements in the soil which support plant growth. This is very true for cassava which is efficient at obtaining its nutritional needs from even poor soils.

It is not possible to make over-the-board fertiliser recommendations for cassava. These will vary with specific site conditions eg soils and climate. Attention must however, be drawn to the importance of potassium as a nutrient in cassava production. Potassium levels are critical if starch content of roots is to be maintained, and adequate fertilisation with potassium fertilisers is usually required to achieve high yields. Nitrogen and phosphorous, together with a range of minor elements may be required in individual circumstances. Whereas some nitrogen is required to balance additional potassium, too much of this element is thought to encourage the production of stem and leaf without parallel root production. It is becoming increasingly apparent that cassava can obtain its phosphorous needs through the agency of a symbiotic relationship with a soil Mycorhiza. However until further research has been carried out it is safe to assume that cassava needs phosphorus and its fertiliser programme should include this element until direct evidence is available to show otherwise.

Where the scale of cassava production operations is large enough to warrant them, field trials should be carried out to decide site-specific fertiliser requirements. Fertiliser costs are sufficiently high to render these trials financially worthwhile.

5.6 Rotation Crops for Cassava

It is sound agronomic practice to grow a series of crops on the same area to avoid build-ups of pests and diseases, most of which are specific to particular crops. This is the case with cassava.

In addition, the slow growth of cassava during its initial stages and the wide planting distance makes the crop a poor protector of the soil from the erosion standpoint. On sloping fields with soils of poor physical structure, growing cassava can result in severe erosion. This effect is compounded by the extensive soil disturbance, unavoidable during cassava harvesting operations. In this case rotating cassava with a fibrous rooted crop, which requires little soil disturbance, assists in the stabilisation of the upper soil profile.

Small farmers traditionally follow a succession of crops, usually related to the gradual depletion of the soil's fertility. Other farmers practise mixed cropping where rows of crops are intercropped between rows of unrelated crop species.

Unfortunately the move towards mechanisation has tended to an abandonment of sequential and mixed cropping.

Many agro-industrial ventures have neglected the agricultural implications of monoculture, and have developed only sufficient land to cater for the raw material requirements of the factory. This makes no allowance for rotation or break crops, resulting in pest and disease build-up, and/or serious soil erosion which cause low yields and the eventual failure of the venture.

The possible break/rotation crops for use with cassava depend on a list of priorities which include climate, soils and food and industrial requirements of each area. Some which may be considered eg maize or groundnuts would involve the agro-industrial venture in the large-scale production of crops in which it had little direct interest. This complicates the agricultural inputs by adding to the list of machinery, to provide planters and harvesters etc, plus the provision of seed, fertilisers and chemicals. Additional buildings for the storage and processing of rotation crops previous to sale may also be required.

Where cassava is the sole product required of the agricultural component of an agro-industrial venture the use of leguminous cover crops/pasture crops is attractive as they require little in terms of additional inputs other than the expanded land area needed to effect a rotation programme.

Leaf meal could be produced using this rotation system, and incorporated into cassava products to increase their protein content. Alternatively the rotation crop could be grazed to provide some economic return. As stated previously the climatic conditions, length of dry season, and soil conditions must be considered carefully before any decision on rotation-crop policy is decided.

Nevertheless the importance of break crops between cassava crops cannot be over-emphasised and the difficulty in selecting an economically or logistically attractive break crop must not be used as an excuse for not following a rotational policy.

6. PROCUREMENT OF CASSAVA

Factories intended to make products derived from cassava have failed in several tropical countries because the procurement of raw materials has not been properly organised.

Among the factors which must be considered in organising a reliable supply of cassava the following are the most important:

- the source of production: should this be farmers or a plantation, or a combination of both?
- the costs of production of cassava by farmers and by plantation methods.
- the material to be used by the factory: should this be perishable cassava roots or less perishable chips?
- the prices to be paid for roots and/or chips
- the quality standards required of roots and/or chips
- the training of buyers to assess/grade roots and/or chips against required quality standards
- the scheduling of collection and transport of roots and/or chips.

Each factor is considered below.

6.1 Source of Production

From the integrated cassava processing factory's point of view the key requirements of the supply of raw material are that it should be consistently available, of the right quality, and priced at a level enabling the factory to operate economically.

The advantages of supplying the factory from its own plantation are those of control over the availability and quality of material. The disadvantages from the factory's viewpoint are that the costs of machinery and hired labour may well lead to a cost per kg of raw material which is higher than the price at which the factory can buy from farmers; and that the plantation must grow break crops, in which the factory has no interest.

From the national viewpoint, moreover, there may well be a policy to encourage cassava as a cash crop for small farmers, which would be defeated by the factory relying entirely on its own plantation.

In each country where an integrated cassava processing factory is being considered it will be necessary to take these factors into account. In the case of Zambia, where cassava is at present almost entirely a subsistence crop, the recommendation is that farmers should be motivated to grow it also as a cash crop, and that the decision to set up a starch, glucose and dextrins factory should not be taken until supplies from farmers are assured. A small plantation should be set up as a supply source of healthy planting stock for distribution to farmers rather than as a major source of tuber supply to the factory.

6.2 Costs of Production

Appendix 3 shows that there is great variation in the production systems which farmers may use in growing cassava. The labour inputs, however, are approximately 77-78 man-days/ha, of which weeding accounts for 30 days and lifting and trimming roots for 19. These figures exclude land preparation.

Appendix 4 shows the mechanisation requirements of a cassava plantation sufficient to provide 40 tonnes of cassava roots a day for 280 days a year. These requirements vary according to the rainfall system: all-year round rainfall permits machinery to be used continually, and numbers of machines needed are therefore lower than those required when planting and harvesting are restricted to certain periods of the year.

The following figures summarise the fob costs, UK port, of the machinery estimated to be required under all-year round, long bi-modal and long unimodal rainfall systems, and the capital costs per hectare. Under short bi-modal and unimodal systems the costs would be higher in total than under those illustrated.

Estimated machinery costs under three rainfall systems

	All-year round	Long bi-modal	Long unimodal
Assumed yield of roots in Africa (t/ha)	18	12	18
Hectarage required (a)	622	934	622
Fob costs, UK port, of machinery required (b) (£000)	131.3	290.8	243.9
Machinery capital costs per hectare (b) (£)	211.17	311.36	390.09

(a) Before allowing for hectarage needed for break crops.

(b) Before allowing for spare parts.

After increasing these costs by 15-20% to allow for spare parts and adding cif charges it is clear that machinery capital costs per hectare under fairly favourable, long unimodal rainfall conditions, could be of the order of £700 per hectare in a location distant from a port; and under less favourable conditions they would be higher.

These costs, together with the price of hired labour, must be closely calculated in evaluating a plantation.

6.3 Choice of Raw Material

Cassava roots begin to deteriorate only 24 hours after harvesting, and it is essential that they are received for processing at the factory before this occurs. This creates formidable logistical problems if the factory relies entirely on fresh roots for its raw material, and has to draw them from an area not immediately adjacent.

Cassava chips, sun-dried by the farmer, are much less perishable than roots. Their yield of starch will not be as high in quality or quantity as that of fresh roots; but it should be adequate for many applications in which starch is used as such, and certainly adequate as a material base for glucose and dextrins.

It may be that, as proposed for Zambia, the factory should rely on cassava chips as its main raw material, but buy in roots from the immediate vicinity for the production of high quality starch.

6.4 Prices of Roots and Chips

Prices will naturally vary from country to country. Any proposed factory will have to calculate what it can afford to pay, working back from the prices which it can get for its products in the market, and judging also the level whichis needed to give the farmer an incentive.

The yield of starch from fresh roots is only 30% of that from dried chips, and it could be argued that farmers should be offered only this percentage of the chip price. However, they incur at least as much cost in producing roots as in soaking, peeling and drying them into chips, and a price based on starch yield would be a disincentive to sell fresh roots.

It will be more effective to offer 50% of the chip price for fresh roots, and to attempt to charge a higher market price for starch made from roots than for the chip-based product.

6.5 Quality Standards.

For both roots and chips the quality requirements are that they should be:

- free from foreign matter (sand, dirt, insects)
- free from mould or bacterial deterioration
- white in colour
- derived from plants of the right maturity.

The fundamental requirement of fresh roots, however, is that they should indeed be fresh. In contrast, the most important requirement of chips is that they should be thoroughly dry.

The drying of chips, right through to the centre, is essential if they are not to rot. Effective drying by sun and wind depends on chip design and on methods of drying, both described in detail in Appendix 5.

6.6 Training of Buyers

In countries where cassava has previously been only a subsistence crop, or where only fresh roots have been used in starch factories, it will be necessary to train buyers in the assessment and, possibly, grading of chips.

We recommend that fairly simple criteria can be applied in the early years of projects based on chips. These should be:

- white in colour, with no peel present
- dry to the touch (tending to rattle when shaken)
- able to pass through a 50 mm screen
- free from foreign matter.

6.7 Transport Scheduling

This is particularly important in the case of roots, and Appendix 3 contains a special note on planning transport methods in dry and wet weather.

The logistical problems of collecting fresh roots were referred to in 6.3 above. It is essential to keep in mind that roots must be processed within 24 hours of harvesting: and that (Appendix 3) it takes 19 man-days to harvest one hectare of roots.

It is therefore a matter for careful organisation when scheduling collection of fresh roots. It may be necessary to go to 5 farms once a day for 5 days, to collect 1 tonne of roots from each, rather than to arrange to collect 5 tonnes from each on successive days. In the latter case, unless the necessary labour is deployed, a proportion of the roots would certainly be over one day old.

7. THE FACTORY CONCEPT: CONSIDERATIONS OF PROCESS DESIGN

A typical analysis of the constituents of fresh cassava root is as follows:

25%	starch & other carbohydrates
2%	cellulose
3%	protein
5%	others
65%	water
100%	

The amounts vary considerably according to such factors as method of analysis, stage of maturity, growing conditions and many others. However the analysis does demonstrate that the main constituent of cassava roots, other than water, is starch, and other carbohydrates. Therefore in designing a factory process, the main technology used and the equipment required will be that used in the starch industry. There are a number of different uses for cassava starch and indeed other parts of the plant. A list of the uses of cassava was given in Chapter 4. It can be seen from this that there are considerable opportunities for the processing of cassava, and that these are mainly starch products. The choice of product to make will be dependent upon:

(a) Availability of raw material
ie root, leaf
stalk
chips

(b) Market size or requirements for products

(c) The shelf life or storability of the product.

The availability of raw materials for a cassava factory is a key issue, as discussed in Chapter 6.

Market requirements have been discussed in Chapter 4, in general and with specific reference to Zambia. Each country, region or area where a processing factory is proposed, should be analysed individually.

The shelf life or storability of the product is perhaps the most important single factor which requires attention at the planting stage. Cassava is a perishable root as soon as it has been harvested, similarly the leaf and stem will also deteriorate rapidly if a process of some kind is not carried out to arrest the spoilage, preserve the product or alter it so that the resultant product will store.

Because the fresh roots and leaves are so perishable, the location of processing facilities often has to be near the production area. A factory sited near to cassaa production could process to an intermediate stage, eg starch, flour or even chips. The product from this rural factory would have a much longer shelf life and could then be transported to other processing facilities or form the raw material for existing factories.

Chapter 6, on procurement, emphasises the need for the introduction of a vertically integrated system of cassava production and processing. This concept therefore requires that the producer makes a product which will keep and can be easily transported to a processing installation or market. A dried chip has been determined as being the most suitable way of doing this. This chip is mainly composed of starch and is the easiest way of storing the commodity until the starch can be extracted.

The cassava processing concept is therefore designed around a starch extraction process. The possibility of deriving some products during the production of starch is considered, as well as the use of dried chips as a raw material. The modification of starches is not considered in detail since the process for doing this uses standard manufacturers' machinery. Information and plans can therefore be obtained from them.

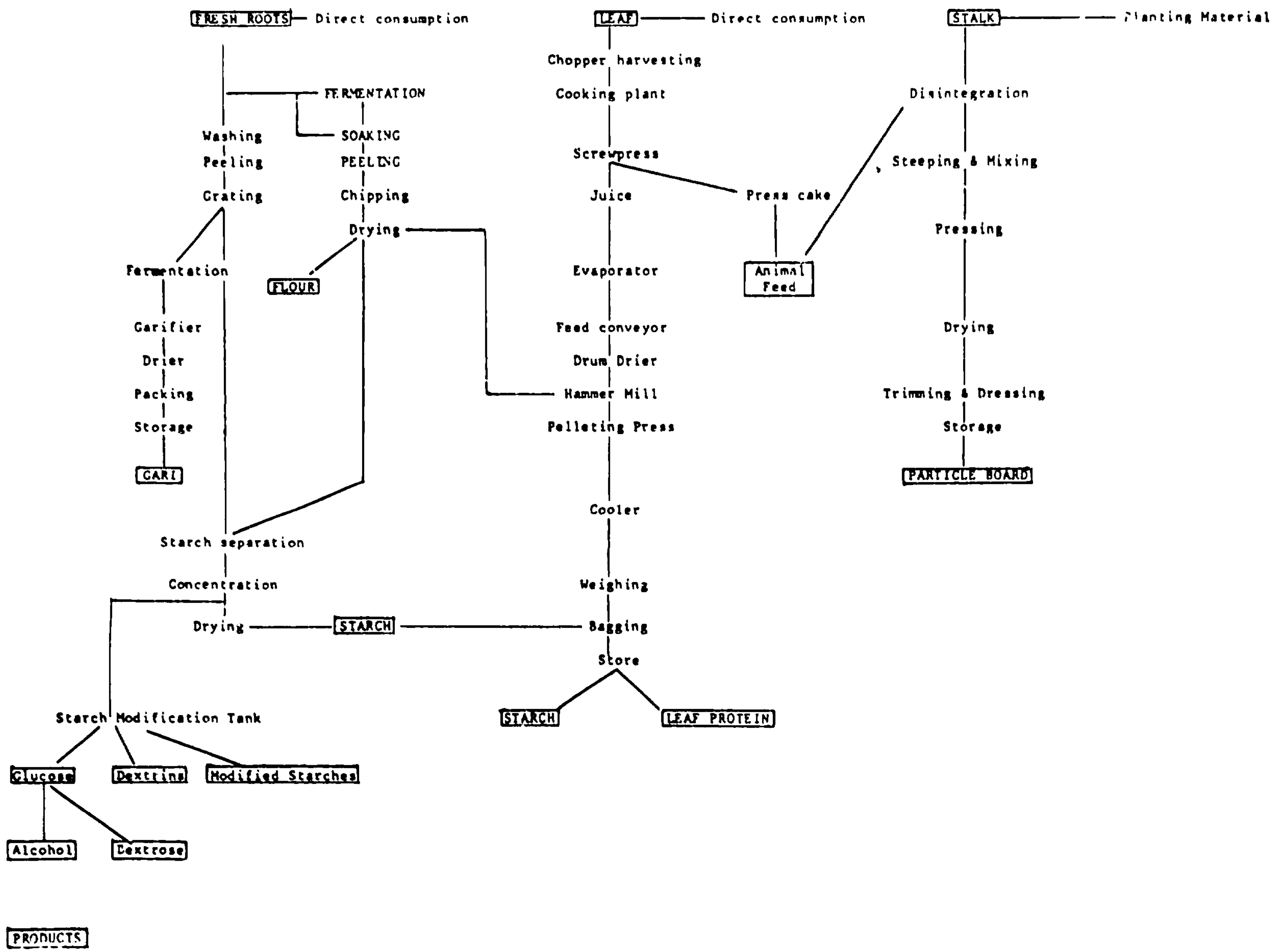
A flow diagram showing a processing concept is shown in Figure 2. It is unlikely that this would ever be built since the demand for the whole range of products or the raw material supply to viably supply each product line would not be available. However, the figure does show the process for each product and therefore a process flow line to suit the product demanded can be planned.

Other considerations which must be taken into account when planning a cassava processing concept of this type are:

- Chip quality, and fresh root availability
- Availability and quality of water for processing
- Market requirements on quality and facilities in the country for further processing
- Effluent disposal standards
- Level of technology required in the process.

A brief discussion expanding the above factors follows.

Figure 2
Cassava: A Comprehensive Processing Concept



7.1 Chip Quality and Root Availability

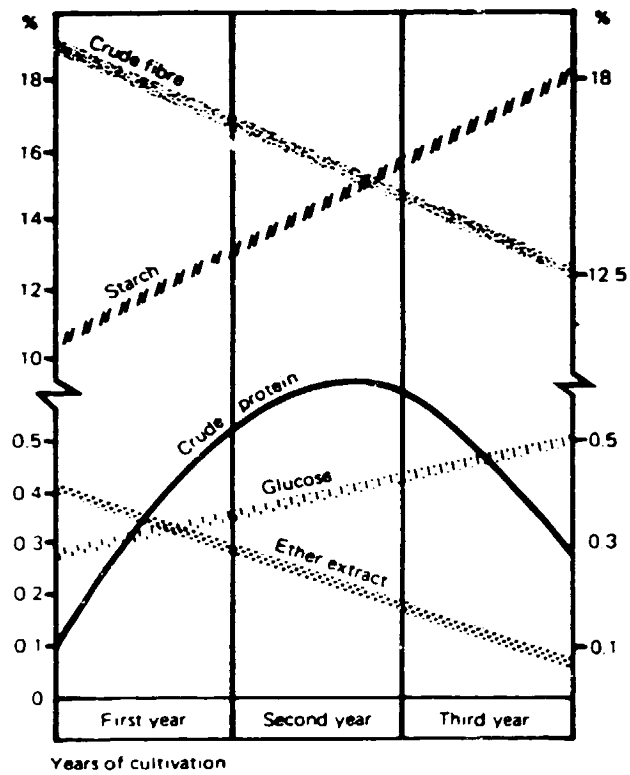
The use of sun dried producer prepared chips is a new processing concept in Africa. In some countries the drying of sections of the root is already practised. (This was seen in Zambia, see Volume 2). In most cases cassava is processed by the producer or villager into a staple product such as gari or flour directly from the fresh root or after a soaking and fermentation stage. Since the "Chip" has been suggested in this report as a means of prolonging the life of the raw material for further processing, it is important that it be properly dried throughout otherwise some deterioration from moulds and bacteria will occur on any damp surfaces. For this reason a discussion on chip geometry has been included to demonstrate that the size of chip exposed for drying is important. Any chips which have incurred mould growth or which have deteriorated because they are wet, will be rejected for processing into starch or other products because the resultant products will also be poor in quality.

Fresh root availability and methods of production have also been discussed. It is important to emphasise that any capital investment in plant and machinery for cassava processing must be run for as long as possible to be economic. Plants awaiting raw material for processing are inherently a poor investment. Thus it is important to ensure that fresh roots are available in sufficient quantity and quality to ensure maximum plant utilisation. Quality is an important consideration and is related to stage of maturity at harvest; variety; growing conditions; and speed of processing after harvest.

An example of the changes which take place in a cassava root over a three year period is graphically shown in the accompanying diagram. From this it can be seen that maximum starch production can be achieved by leaving the root to mature. However, from the production and processing point of view, this may not be ideal.

Figure 3

Trend of the nutrient content in cassava tubers during 3 year growing period



7.2 Water Quality and Quantity

The traditional method of extracting starch from cassava is a wet process designed to wash out starch granules from a pulp and to sediment out these granules from the suspension. In small rural factories, up to one tonne per day this is still done on settling tables or in tanks. Settling tables have a very slow flow of starch milk (starch in suspension in water) over a series of inclined trays. The starch particles precipitate out of suspension onto the tables. Varying quality according to granule size can be achieved since the larger or heavier starch granules will separate out first. In modern processing factories, capacity 1 tonne per day plus, the settling out is speeded up by the application of centrifugal force. Centrifugal separators remove the starch granules, and here, varying speeds can be used to obtain differing quality. It is important for quality reasons that the starch be removed from the starch milk as soon as possibie since a starchy milk is a good media for the growth of moulds. The centrifugal separation process is therefore efficient and effective at removing starch from the water.

The quality of the water is therefore important, since it will be in contact with the starch and must be of potable quality. It should be potable from the point of view of being free from bacteria or mould spores and it must also be of good chemical quality. Free ions of copper or iodine will affect the colour of the starch.

In the dextrin process steam is required for heating the starch. Where boilers are required, suitable water quality in terms of level of salts of calcium (ie hardness) is also important.

Since the centrifugal process is a wet one of continuous washing and extraction, the quantity of water required is large. A typical example would be a water consumption of 4,300 litres for every tonne of starch produced (ie a 4.3:1 ratio). Some water can be re-used on the modern processes which is reflected in the above figure. Older processes required as much as 16,000 litres/tonne of starch.

In view of this high water demand and since cassava is often grown in areas of the world with low or very seasonal rainfall, we have investigated the possibility of extracting starch using a flour sifting technique rather than a wet process. A dry technique would be feasible depending on the quality and use of the resultant starch. A dried chip would have a starch content of approximately 85% and, depending on the stage of maturity of the parent root, the fibre contained in the chip could be sifted out. This starch product could then be used for dextrin manufacture or even glucose manufacture. Its quality would be poor for food uses since the proteins and fat still bound up with the starch might affect its viscosity and heating properties. Similarly the product may have some application in textile sizing but its boiling qualities would be variable.

The above demonstrates the importance of considering the end product from a cassava factory since a dry process would be cheaper in both capital terms and in use of water, especially if the water needs to be treated before use.

Further research work on the dry processing of cassava starch needs to be done. Some work is already quite advanced on potato starch and this may be applicable for cassava.

7.3 Effluent Disposal Standards

The extraction of constituents of cassava can never be 100% efficient, and depending on the sophistication and thus capital cost of the factory, the efficiency of extraction will vary. In the wet process some product will be lost as soluble sugars in the waste waters, and these sugars provide nutrients to bacteria and microorganisms which ferment and often produce the odours associated with starch or agricultural processing plants. The starch water will need to be treated as it leaves the factory. This can either be a simple ditch and weir system allowing some precipitation of suspended solids, or it may be a more complete effluent treatment plant to ensure organic matter is digested in a more controlled manner. Much will also depend on the disposal of by-products such as the fibre extraction. If this is dried and sold for animal feeds, then there will be mainly a liquid effluent disposal problem. Whatever manner it is dealt with, the disposal of effluent willneed to be considered in the light of the local and government legislation, the quality of the effluent being disposed of and the resources available in the vicinity of the factory, eg rivers, streams.

7.4 Level of Technology Required in the Process

The level of technology required will be dependent upon scale of operation and the market requirement. One other consideration will be location of the factory. Sophisticated factories in remote areas are often difficult to service both technically and managerially. Factories should be simple and appropriate to both location and skill of operators using the plant. The location of the processing facility may also be determined by its proximity to the growing area, which may cause the location to be in a more remote area. In these instances a simple "extension of raw material life" type process is the most appropriate and shipping to further processors in an industrially developed region of the country would save the cost of the factory providing its own infrastructure and service industry.

7.5 Leaf Processing

In Zaire, as an example, it is estimated that in rural areas 60% of the diet is derived from the cassava plant and that leaves are plucked from cassava every two months. The leaves are normally boiled and used as a spinach. They are high in nutrients and therefore have a good food value.

Comparison of Nutritional value of Cassava Root and Leaf

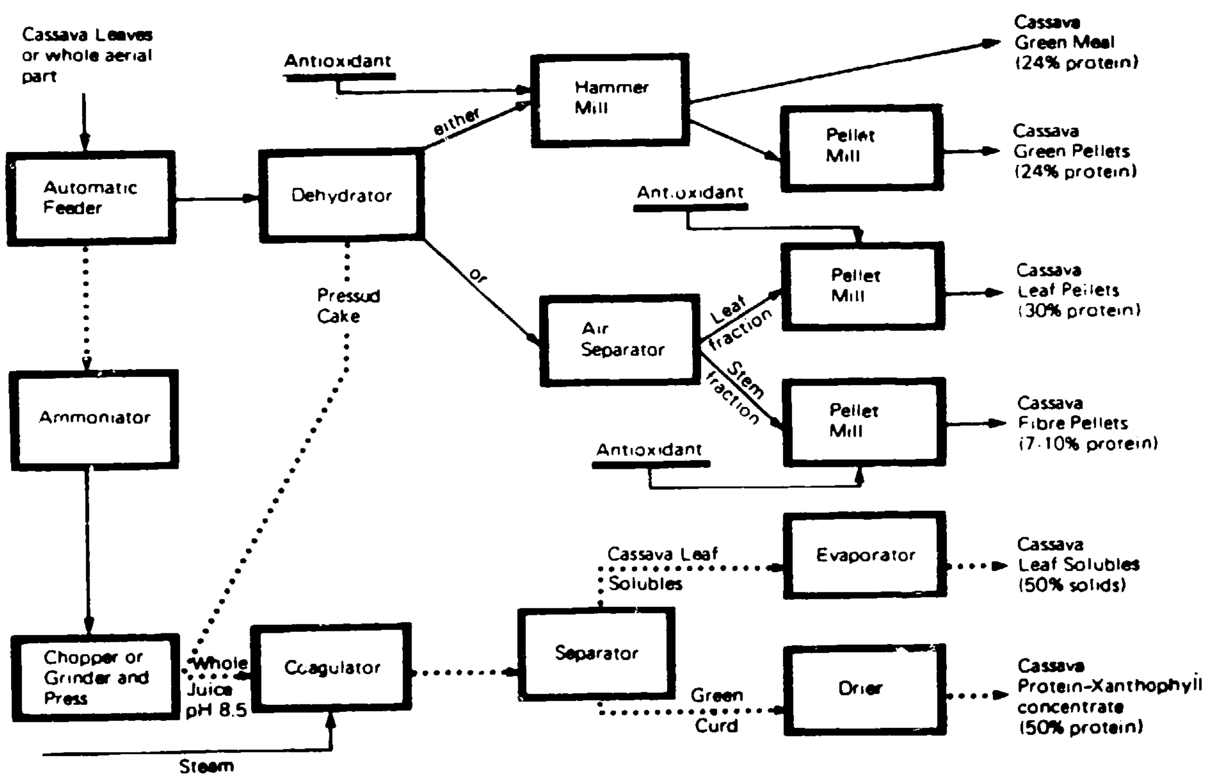
Food Composition	Units/ 100 gms	Raw Root	Raw Leaf	Potato
Food energy	Calorie	135	60	82
Moisture	Percent	65.6	81.0	77.7
Protein	gms	1.0	6.9	1.7
Fat	gms	0.2	1.3	0.1
Carbohydrate	gms	32.4	9.2	18.9
Fibre	gms	1.0	2.1	0.6
Ash	gms	0.9	1.6	0.9

Source: Leung, Butrum and Chang, 1972.

The biological value of leaf protein is between 44-59 due to the low levels of methionine (an essential amino acid in the protein). If the leaf is supplemented by this at 2 gm/kg, then the biological value of cassava leaf is raised to that of fish or meat. Thus provided people on a cassava-based diet supplement their diet with protein from legumes or fish, then a well balanced ration should be achieved. Leaf protein extraction from cassava is not generally recommended since the crop is normally grown for its roots and cassava is not a plant with a large leaf area. Experiments have shown that some defoliation every two months has little or no effect on root yield, however any off-take greater than this will seriously depress root yield. Other more leafy crops are therefore recommended for leaf protein extraction on a large scale.

Figure 3a

The commercial potential of the utilisation of the aerial part of cassava (modification of the PRO-XAN process)



The possibility of integrating a leaf protein extraction plant into a cassava processing plant would be a logical concept, especially where cassava is produced on an estate basis. To elaborate this concept further in the case of estate cassava production, the alternative crop to cassava grown in the rotation could be a leafy crop. Such a crop as alfalfa (lucerne) or even a grass cover would be a useful break crop to cassava since a legume would restore some fertility back to the soil or a grass crop could be ploughed back into the soil, providing during its life an opportunity to treat broad leaf weeds which may be a problem in cassava and to provide a break from cassava diseases. The break crop may also provide grazing or feed for livestock but more relevantly the crop could be used for leaf protein extraction. Thus a possible concept would be a cassava factory producing gari or cassava flour and a leaf protein extraction factory, using some common plant producing leaf protein. These products could be mixed to form a nutritionally balanced meal for both human and animal feeding or could be sold separately.

Since the dried products would store well, the possibility exists of using the same factory to produce leaf protein in the wet or rainy season (a period of maximum leaf growth) and cassava flour/gari in the dry season (the period most suitable for root harvest). The products could then be mixed at a convenient time of the year. In this way a factory could be operational 12 months of the year. Much of the equipment used in such a factory is common to both processes providing a saving on capital. (A flow diagram of a leaf protein process is given in Figure 3a).

On further investigation of this concept, the consultants have found very little relevant research work and indeed leaf protein itself is still a somewhat untried product. It would appear that marketing a balanced meal of this type or even leaf protein, is the present constraint. In Nigeria, where the enrichment of gari would appear to be an obvious market opportunity for the urban poor, the concept of leaf protein is still in the experimental stage. Some feeding trials have been done but there has been no attempt at marketing on a larger scale.

In conclusion, therefore, we would suggest that a leaf protein cassava flour complex be looked at in more detail and perhaps a pilot production and marketing trial set up. The technology for both processes is available and could be engineered and therefore such a factory may find a new market opportunity.

8. OUTLINE OF INTEGRATED CASSAVA PROCESSING FACTORY

In this chapter we describe the integrated cassava processing factory and its procurement system as proposed for Zambia. In other countries the circumstances of raw material supply and market demand will vary; but an operation on the scale proposed will probably be applicable to a number of other countries, and to regions in countries of larger population.

Layouts of the proposed Zambian factory are shown as Appendices 8 and 9 and a list of machinery required is given in Appendix 10. Appendix 11.1 gives details of manufacturers able to undertake turnkey projects, and Appendix 11.2 shows those with experience of supplying some of the machinery required.

8.1 Procurement Supply

The factory proposed in this report is a new concept for the African situation since the major source of raw material is cassava chips and not fresh roots. We believe that, if a sufficiently well organised marketing system can be arranged which would not only ensure adequate quantity but would also ensure a quality chip suitable for processing, then the processing of cassava on a commercial scale becomes a very real possibility.

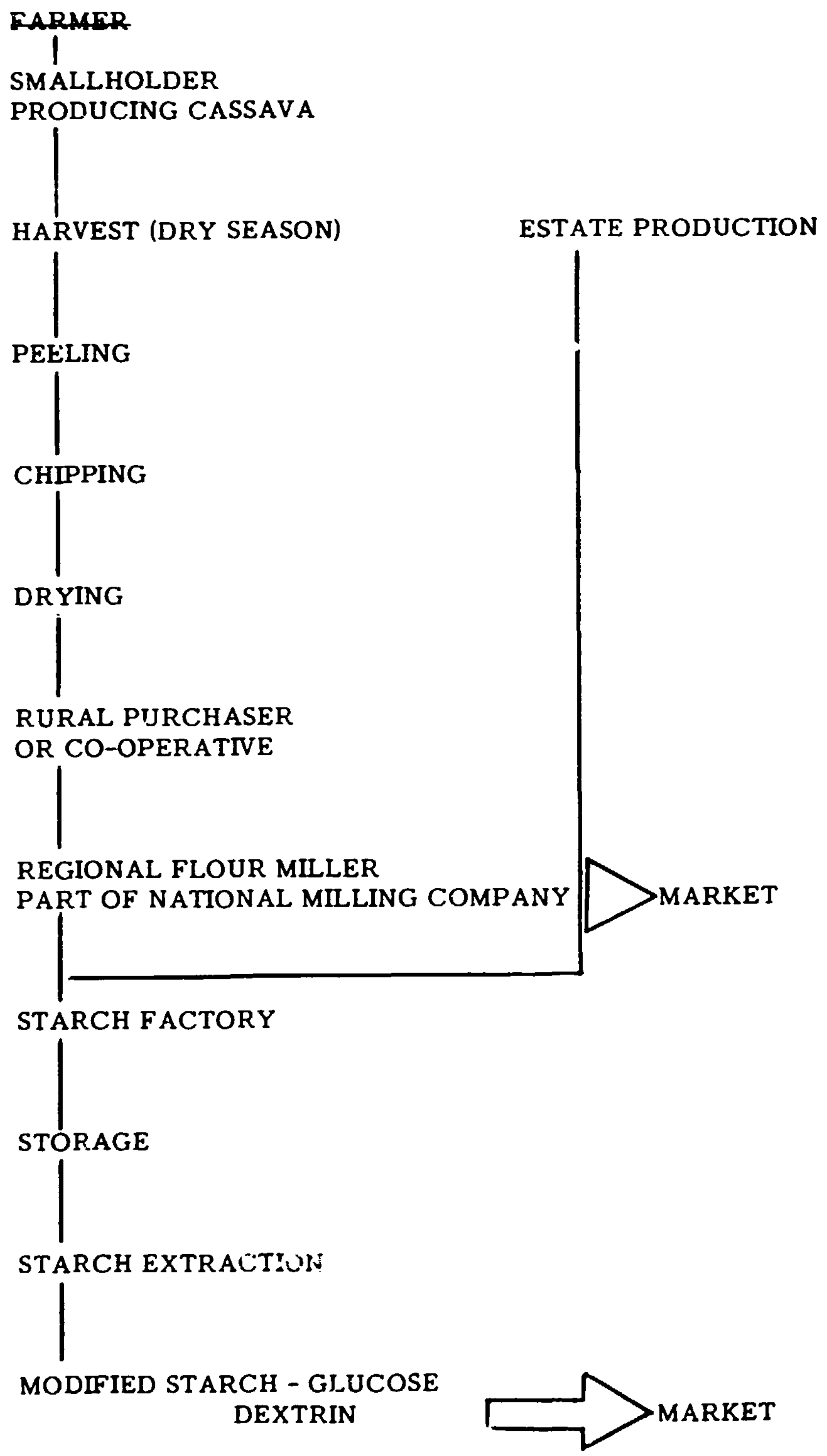
An outline of the proposed factory and associated collection system is shown in figure 4. The recommended system of procurement of chips is described in volume 2 which is designed to ensure that the chips are purchased during the dry season and stored at the factory for later processing. In the case of Zambia this could conveniently be done through the national crop buying organisation (NAMBOARD).

It is proposed that a considerable quantity of chips collected be processed into flour through the existing maize mills. The product would be used in the national dish, Nshima, or could be stored or substituted for maize as a reserve. It is therefore proposed that the cassava starch factory only process that quantity of chips which will be surplus to demand for flour production. However a flour production line has been provided in the process to allow the factory to produce flour since the factory's location may be in an area where there is currently no national mill.

Since the factory would purchase chips from the government marketing system it would not have to have a large purchasing force of its own. In some countries however this team may be crucial to ensure adequate supply of chips to a factory.

The factory would not be built in the Zambian situation until the system of production, buying and milling of chips was well established.

Figure 4 - PROPOSED FACTORY & ASSOCIATED COLLECTION SYSTEM



8.2 The Starch Process

The concept of starch extraction from sun dried chips is uncommon. Standard designs and equipment are not generally available from companies specialising in starch processing. Normally starch from chips would not be recommended since the quality of the resultant produce can never be as good as starch drived directly from the fresh roots. There is therefore little experience on the quality and uses of starch produced from chips. However for industrial purposes (textile sizing and glues) and as the raw material for glucose manufacture the product should be of adequate quality.

It is proposed that the factory described in this report should also have the capability of processing some fresh roots for the production of high grade starch.

8.2.1 Starch from Fresh Roots

The extraction of starch from fresh roots will be done on standard equipment designed for the extraction of starch from potatoes. The process relies on the use of centrifugal force to separate the starch granules from a water suspension.

Fresh roots will be supplied daily to the factory from surrounding smallholders and possibly from a small plantation set up on the Government research station just outside the town of Kasama. This small plantation is advised for the supply of new planting material for the Zambian farmers and which will, when harvesting planting material, also supply roots to the factory at Kasama. We would recommend that any starch or cassava processing scheme have some facility or system of promoting the use of high yielding varieties in the area which assists the farmers in obtaining higher yields of roots per unit area of their land. This normally means that some research or trials area needs to be established to provide information on the most suitable varieties of cassava for a given region. Once the variety has been determined then the regular supply of clean planting material to the farmers assists in controlling disease levels in the region. It also provides a centre for agricultural extension and demonstration for small holders. The resultant roots are available for any nearby processing facility.

The rated capacity of the starch factory is planned at an output of 1¼ tonnes starch per hour. This scale is too large for the processing of fresh roots and is designed mainly for chip processing. To supply such a line with fresh cassava roots would require approximately six tonnes of roots per hour (Approx 50 tonnes/roots/day on an 8 hr processing day). This is a considerable undertaking since the average yield of cassava is often below 10 tonnes per hectare and therefore the physical harvesting of 5 hectares per day all the year round is the logistic problem most commonly cited in the poor performance of cassava plants already in existence. This output may be possible from an estate or plantation, but the problems discussed in Chapter 6 above make this uneconomic in Zambia.

It is therefore proposed that only 5 tonnes/day will be processed at the factory for a maximum of 150 days during the dry season, when the quality of roots is at its best. The fresh roots will be from 18 months to two years old. This will mean that the starch level wiil be high, but the roots may have become rather woody and fibrous.

We calculate that the extraction of starch from these roots will take 1¾ hours per day. This process would be carried cut as the last process of the day before cleaning down. The remainder of the day would be spent on washing and peeling and rasping of the roots. Since the peeling can now be done by hand (due to lower throughput) considerable savings can be made on the amount of root actually processed. Mechanical peelers presently marketed have been designed for potato and therefore losses of up to 25% of the root have been recorded when peeling a root the shape of cassava.

The process flow line to the point of starch extraction is therefore as shown in Figure 5.

The material balance and water requirements are shown in Figure 6 showing the whole starch process from fresh roots.

Much of the machinery for this stage of the process can be locally made out of mild steel. There is a well established ability in Zambia to produce on-farm milling equipment and these fabricators could readily assemble the conveyors, washers and rasping machines to a specified design.

Figure 5

PROCESS FLOW LINE FOR PREPARATION OF FRESH ROOTS FOR STARCH EXTRACTION

FRESH ROOTS	5 tonne/day
WEIGHING	Platform Scale & Tared Buckets.
WASHING	Rotary Tumble Washer (recycled water)
STORAGE	Open Silo
PEELING	By Hand
WASHING	Rotary Tumble Washer (Raw/Fresh Water)
CHOPPER	Size Reduction Slicer
DISINTEGRATOR	Rotating Rasp of Local Manufacture.
SLURRY TANK STORAGE RESIDENCE TIME MAX 12 HOURS	Stainless Steel Vat with Facility for Dosing with Sulphur Dioxide (SO_2)

Figure 6

TYPICAL MATERIAL BALANCE SHEET FOR CASSAVA STARCH PLANT

1 TONNE FRESH ROOTS
350 KG DRY MATTER (DM)
650 KG WATER

WASHING AND PEELING
310 KG DM
750 KG WATER

RASPING
310 KG DM
2950 KG WATER

EXTRACTION
310 KG DM
6450 KG WATER

REFINING
220 KG DM
370 KG WATER

DRYING
220 KG DM
30 KG WATER

Root Preparation to Slurry

Root slurry is the term used in this report for the disintegrated root material which is awaiting starch extraction. In some cases it is referred to as starch milk.

Since storage for a maximum of 12 hours will be required it will be necessary to introduce Sulphur Dioxide (SO^2) as a preservative for the starch. This prevents fermentation by bacteria from occuring and preserves the colour of the slurry. There will be a tendency for browning to occur due to enzyme action and this is prevented by the addition of SO^2. The chemical will tend to have a bleaching effect.

The maximum holding time of 12 hours assumes that the processing day will be a total of 16 hours (2 shifts of 8 hours). Two hours will be required for start up and cleaning down, approximately ½ hour start up and 1¾ hours cleaning down at the end of each day. The roots will arrive and be stored from the previous day's harvest and will therefore be available for immediate processing as the factory starts in the morning. The roots will then be washed and await peeling which would take some time (estimated that 1 tonne could be peeled by hand in one hour using 10 women). Women have been found to be more adept at removing the peel with a knife than men. Piece work rates could be considered for this task, especially since the harvest is only for a certain period of the year.

Following peeling the roots would need to be further washed to remove pieces of peel and dirt. The design of the washer would be similar to that used before peeling and would consist of an inclined perforated drum. The drum rotates in a bath of water and the roots travel from the higher end and are retrieved at the bottom by a conveyor. Brushes may also be fixed to the side of the drum to have a further cleaning effect. Raw or clean water would be introduced in the second wash but could be circulated and used for the roots prior to peeling, the first wash removing soil and sand adhering to the roots. Some drying out of the roots will occur whilst they are in storage overnight which should facilitate the removal of adhering soil if the roots are forked into the washing machine.

Following washing it is necessary to break up the roots and release the starch. Starch is contained in the cells of the plant as granules. To obtain the maximum starch it is necessary to break each cell and this is done by rasping. In the process shown a size reduction known as chopping is shown which will cut the roots down into small pieces ready to be pushed against a rasping drum. Large pieces will tend to bridge or not be in contact with the rasp effectively. The rasp or disintegrator can be a simple machine such as a roughened drum rotating at speed against a quantity of the roots. This will have the effect of grating the root material and breaking it up into a fine slurry. The root being high in water content should provide some liquid to form a slurry which will flow into the slurry tank. Additional water to assist the process is added over the rasp to increase the extraction of starch from the plant tissue.

Before the slurry enters the tank a simple sieve may be incorporated to extract large pieces of fibre and root material which has not been disintegrated.

Starch is composed of complex chains of sugar molecules which are insoluble in the quantities of water forming the slurry. However some of the sugars will not be complexed into starch chains or molecules and will become soluble in water. These soluble sugars will be lost in the waste water. The amount of loss is related to the stage of maturity of the roots. High soluble sugars in the waste water can also lead to effluent disposal problems since these sugars provide nutrients to bacteria and other organisms. The effluent may then begin to ferment.

It is recommended that the slurry tank be constructed of stainless steel or some other non-ferrous metal. The reaction of iron with starch will cause discolourisation of the starch. Cleaning of the equipment will also be facilitated if this vessel is constructed on stainless steel.

Fibre Extraction from Slurry

The starch at the slurry stage is in suspension in water and the final process for the extraction is by centrifugal force. This process separates suspended solids from a liquid. Since the liquid will also contain other impurities such as fibre these need to be removed first. The slurry is therefore passed through sieves to remove the larger fibre particles. Further amounts of water are added at this stage to assist the flow. Sulphur dioxide water is also added to maintain starch quality.

The fibre which results from these sieving operations is then pressed to remove excess water. The press consists of a rotating drum slung on an endless belt. The fibre is pressed between the drum and the belt. The press reduces the moisture content of the fibre from 93% to 78% approximately. The fibre should have a moisture content of 12%. This is usually achieved by sun drying since the installation of a drier for the fibre cannot be justified on cost. The drier used for the starch is not suitable for fibre so there would be no advantage in attempting to use the drier for two functions. Fibre is sold as an animal feed. In Zambia this could substitute in the ration for maize.

Starch Extraction from Slurry

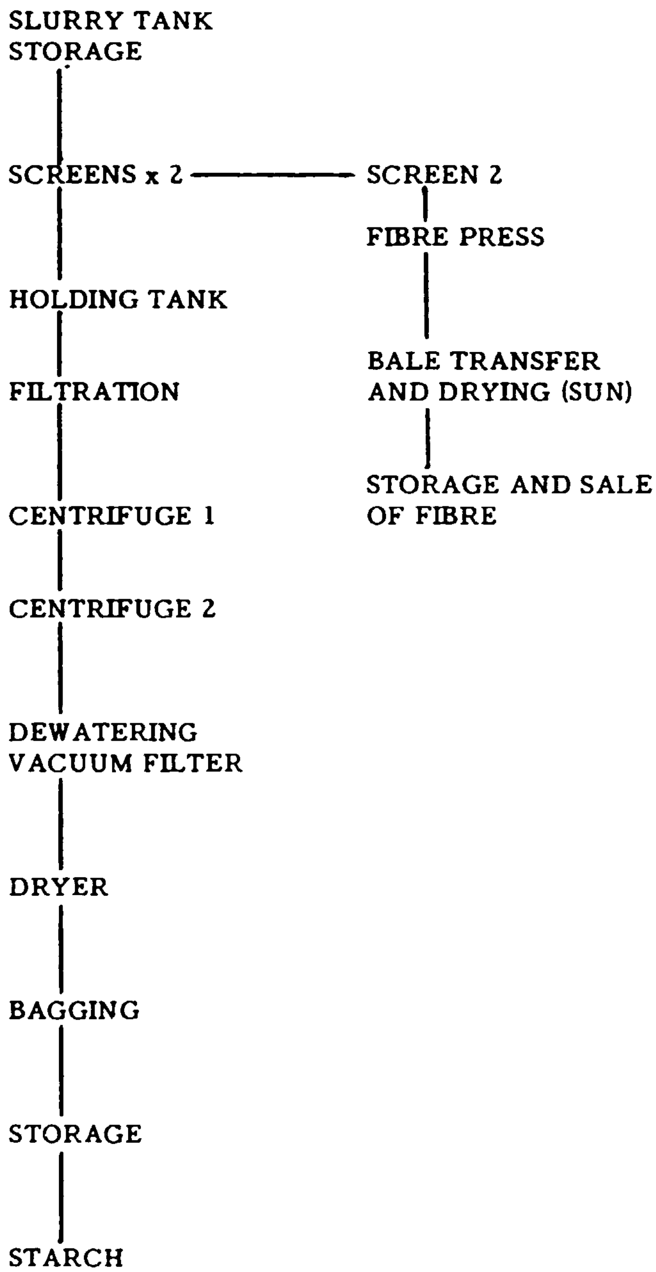
The press water or starch milk with the fibre extracted will now contain soluble sugars, starch in suspension, protein, fat and other foreign matter in suspension or solution. A further filtration is carried out using a much finer mesh which removes more pulp. This can be incorporated in the fibre. The main extraction process then follows. The starch milk is centrifugal twice to remove the starch. This considerably reduces the water content. A further dewatering is done through a rotating vacuum filter before the wet starch is passed to a drier for the reduction of moisture content from 40% to 12%.

At a moisture content of 12% the starch will be stable and will store for considerable periods. In this state it may be bagged or kept in bulk for sale. Drier temperatures are important since the high temperatures will cause gelatinisation. A temperature above 70^{0}C will cause gelatinisation resulting in an insoluble starch product. The lower temperatures are achieved by using a flash drier. These types of driers reduce the residence time of the particles in the drier, thus ensuring that high temperatures around each particle are not achieved. Steam is used to heat the drier and therefore a boiler must be provided for the factory. In the Zambia situation this will run on coal brought by rail to the factory. Steam generation may be an important consideration in other installations in Africa with regard to fuel and water availability and cost.

Dry root starch from the drier would be packaged in 25 kg paper sacks with polythene liners. This would be stored awaiting transport to the consumer.

The conversion of chip slurry to starch follows the same flow line and this is the reason for processing root starch for only 1½ hours per day. The rest of the day the plant is used for chip processing.

PROCESS FLOW LINE FOR STARCH EXTRACTION FROM SLURRY (CONTINUED FROM FIG 5)



8.2.2 Starch from Chips

Chip Storage

The cassava chips would be purchased by the factory from the National NAMBOARD marketing system. This organisation should co-ordinate the buying and processing of the chips into flour. It should therefore be aware of the location and quantity of any excess chips in the region of the factory.

Since chips are only produced in the dry season purchases and storage will need to be provided to enable starch processing to continue for the full 240 days per year. The total chip requirement over the first production year is estimated at 3300 tonnes. Assuming 24 weeks are during the rainy season then the minimum storage would be 1,650 tonnes. To allow a working store of chips we recommend a storage capacity of 2,000 tonnes. These would need to be kept under cover in an A frame building in bulk on the floor.

We recommend that the use of solar heated convection be tried in such a building. This system means that the roof of the store would be double skinned. The outside surface exposed to the sun would be painted black. The sun will heat the air between the roof (the space between roofs being approximately 10 cm). The heated air would be ducted down to the floor and allowed to rise through the stored chips via ducts. This system would have no running costs but would ensure that dry air is passing through the chips and maintaining them in a dry state whilst they are in storage. This is a further concept so far untried with cassava but has been experimentally tried with grain. Since cassava chips may tend to be hygroscopic the circulation of air through the bulk of the chips should be attempted.

The size of the storage capacity would need to be 3,600m^3. (1.8m^3/tonne chips). The dimensions of such a building to accommodate this would be 10m eaves height, 15m standard span x 25m long. (Floor area for storage only 750 sq.metres at a stack height of 5 metres). Standard A frame building should be used where possible.

Chips arriving at the factory by lorry would first be check weighed over a weigh bridge. This would be possible in the Zambian situation if the chips were purchased in bulk from NAMBOARD. However, in a rural situation where control of chip quality is difficult delivery should be in sacks so that each could be checked for quality and the absence of foreign matter such as sand and stones. Bags or lorry loads could then be dumped at the foot of an elevator which would enable one to achieve a heap of chips to a height of approximately 5 metres.

Whilst the chips are in store the solar heated air could be blown through them.

Chips to Slurry

The dry chips would be taken out of storage using a tractor mounted bucket or shovel. These would be dumped in a sleeping or chip preparation area. This area would simply be a separate floor near the process area which has a drain or gutter and where the chips can be soaked with water. This should preferably be done about 8 hours before processing, and could conveniently be done whilst the fresh roots are being processed at the end of each day. The moisture content of chips in store would be approximately 12%. Any moisture content higher than this would not inhibit mould growth and deterioration of the chips. The soaking would increase the moisture content to about 40% which will soften the chips and make them considerably easier for processing. The 8 hour delay enables the chips to absorb the water. (21 tonnes to be soaked per 14 hour process period). Floor area required approximately 76 square metres at a 0.5 metre depth of chips.

The soaked chips are then pushed manually to the reception pit of a bucket elevator. This conveyor conveys them to a rasping machine similar to that for roots. Further water will be sprayed into the machine during the rasping process. The rasping of chips has the same effect as on the roots, that of breaking the plant cells and releasing the starch.

Some losses of loose starch and other particulars will occur in this washing process. For this reason water is reused by recirculating it to the rasp in a screed and hydrocyclone, and effectively remove sand and other particles from the water.

The rasped chips are milled to a fine pulp by the rasps and together with the added water now form a slurry. This is then pumped to a holding tank or slurry tank where it will be processed for starch. Agitation is needed on this tank to keep the starch in suspension and to ensure an even flow of slurry to the next process.

At this stage the slurry from the chips is the same as that for roots. The onward processing to starch is therefore as described.

Figure 7

CHIPS TO SLURRY

CHIPS	-	2000 ton ventilated store with solar drying floor
SOAKING AREA	-	moved by mechanical shovel to floor with central guttering
SOAKING	-	8 hour soaking. Water is hosed over the chips which are sread out on the floor (76 sq.m).
ELEVATOR	-	Bucket type - hand fed by pushing chips into reception pit
RASPING	-	Water addition. Rotating rasps to release starch
SLURRY TANK	-	Starch milk

8.2.3. Chips to Glucose

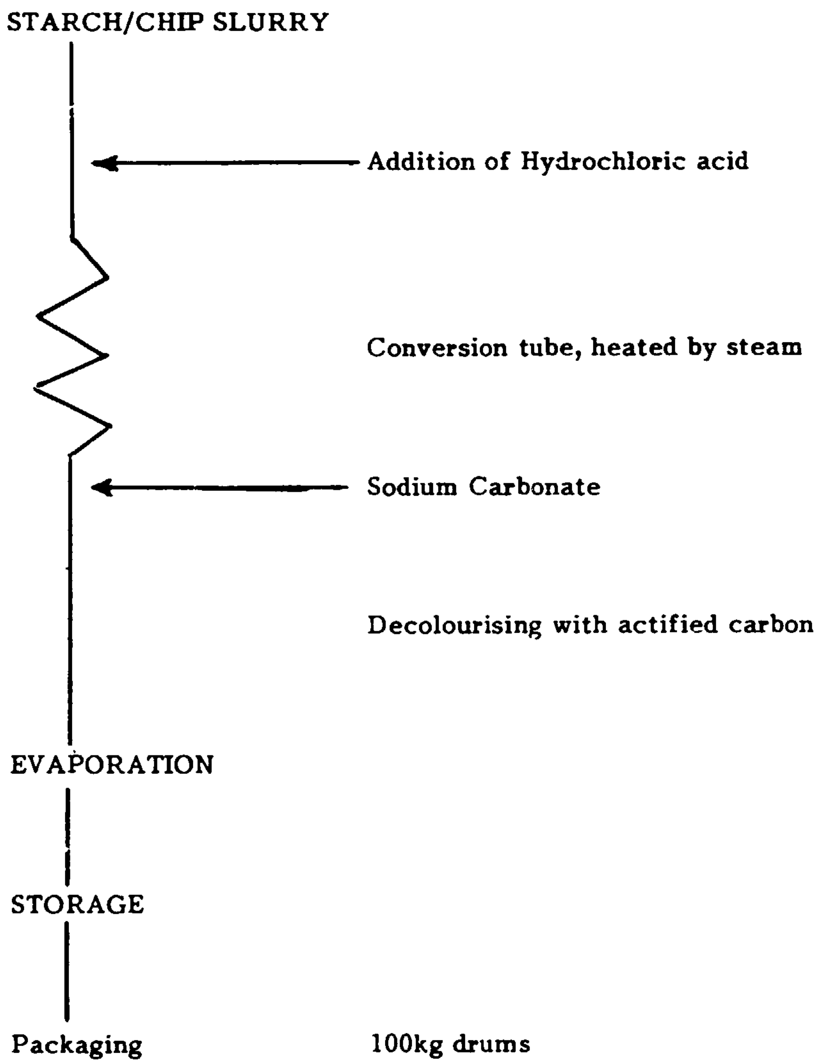
Over half the world's starch production is estimated to be converted to glucose. This is done by the action of acids, or enzymes or a combination of the two. The action of these agents is to break down the long starch molecule into its consistent elements, the starch molecule being mostly composed of glucose and simple sugar units. 100% pure glucose is know chemically as dextrose. The production of Dextrose is more elaborate and costly than only going part of the way to Dextrose. Thus the concentration of the glycose syrup, which is the Dextrose process, is known as the Dextrose Equivalent. For example a D E of 50 means that there has been a 50% conversion to pure Dextrose. Pure Dextrose has a powerful reducing property and can be measured and in this way the D E value can be applied to qlucose syrups. The other 50% of the syrup referred to in the example will be composed of short chain sugars such as Dextrins. In most applications the presence of Dextrins in the syrup is not important and may be even advantageous.

The most widely used glucose (known as confectioners glucose) has a DE value of approximately 42% and a moisture content of 16-20%. This is produced by the acid process and is the easiest process.

It is recommended, to avoid expenditure on capital equipment to produce a product too refined for the market, that only an acid hydrolysis plant be installed. These plants are in themselves expensive and are little more expensive if the raw material is dry starch rather than slurry. Because of this we have considered in the economics of the cassava concept the possibility of only producing starch in the factory described. Glucose could be produced elsewhere, perhaps Lusaka (in the case of Zambia), where there is likely to be better facilities for food processing than in say Kasama. This may be even more relevant in a case such as Zambia where glucose is required as a brewing substrate in substitution for malt. In this instance the conversion of starch to glucose, indeed even the conversion of cassava flour to glucose would best be done on the brewing premises. This would save considerably on packaging and transport costs and would mean a simplified process could be installed producing a glucose to the DE value required by the Brewer. The brewing industry requires a DE value of approximately 55-56 and in the case of Zambia is the largest consumer of sugars, or malt in the country.

Figure 8

~~CHIPS TO GLUCOSE DIAGRAM~~



The acid used in the conversion is hydrochloric acid, although sulphuric and oxalic are used in some parts of the world. The acid conversion process is much quicker and also less costly since less conversion vats are required. The acid is later neutralised with sodium carbonate. These chemicals are normally readily available.

Chips for glucose extraction will be stored, soaked and rasped into a slurry the same way as described for starch manufacture. Starch from the slurry tank is then preheated with steam before being pumped to the converter. Hydrochloric acid is metered into the stream and as the temperature rises the starch begins to gelatinise. Temperature of conversion being approximately 80°C. The residual time for the conversion to take place is achieved by running the heated, acidified slurry through a spiral tube. Directly after acid conversion the syrup is neutralised with sodium carbonate. The syrup is then cooled to approximately 50°C and then decolourised by passing the syrup through an activated carbon filter.

Finally the syrup is concentrated by evaporating the water off the liquid under vacuum. The resultant syrup is then held in heated containers to aid flow before being filled into 100 kg metal drums. The syrup will have a light yellow colour which should be acceptable for most standards. If the market demands however this can be removed by ion exchange methods.

The conversion of starch to glucose is a standard process used all over the world. Maize starch is now the most common raw material for the manufacture of glucose syrups. The advantage of maize being that the starch is often the by product of the vegetable oil industry and therefore the raw material is obtained cheaply and syrup manufacture is often associated with the same factory. In the Zambia situation however where maize is in short supply for human needs the use of cassava is far more appropriate. Further design and process considerations must be made when a future plant is purchased since such factors as syrup concentration or DE value to be produced will affect the cost of the plant. The concentration will be dependent upon market requirements as will the scale or throughput of the factory. Suffice it to say therefore that for the purposes of this report glucose syrups manufacture is both possible and relevant in the Zambia situation. The more precise details of the plant should be planned at the detailed design stage where standard glucose plant and technology can be used.

Properties and uses of glucose syrups are described in Appendix 6.

8.2.4. Starch to Dextrin

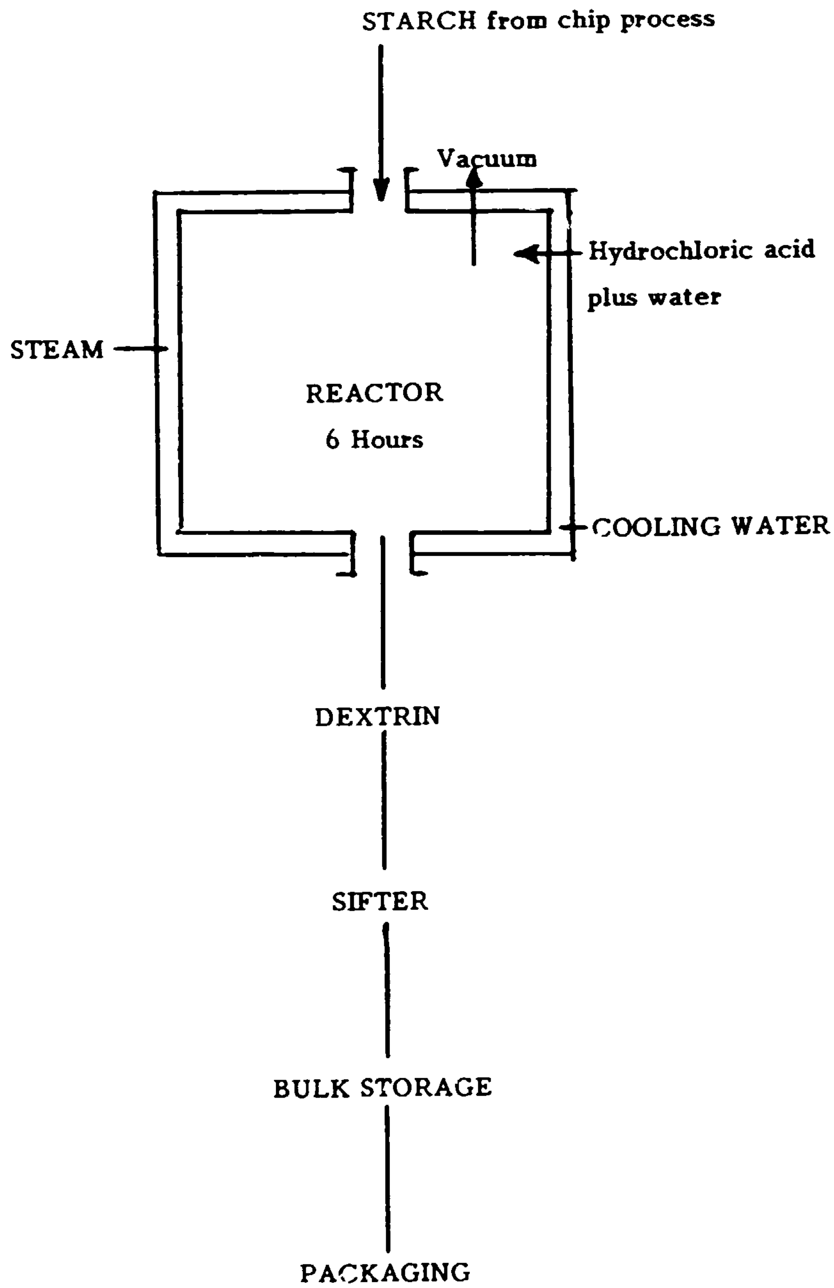
Dextrin is the term used from the products obtained by treating starch in a number of ways. They may be prepared by a wet or dry process either by acid or enzymes or under carefully controlled heating conditions. Once again standard equipment is available for Dextrin manufacture and therefore careful planning considering the markets and the quality of product required is essential. Both batch and continuous processes are available and unless the quantities required are very large we would recommend a batch process. The batch process is also most easily accomplished using the dry process.

The starch with a 12 percent moisture is filled into a reactor. This is a closed vacuum pressure vessel holding 1 tonne of starch. The reactor also contains a high speed mixing paddle and is surrounded by a jacket for heating and cooling the vessel. After filling hydrochloric acid is added in a measured quantity. This is normally done through a metering pump which measures the quantity of acid introduced. The vessel is then heated and a vacuum applied to remove any moisture in the starch. Once dry the reaction is allowed to take place under the action of acid and heat. Finally water is added to bring the moisture up to 12 percent again ready for sale. The product can then be cooled. The Dextrin is removed from the bottom of the vessel and conveyed for packaging in 25 kilo bags.

The total reactor time for yellow Dextrins is 6 hours, white Dextrins take less time. Under the proposed factory therefore two processes could be carried out each day on a 16 hour day. If the Dextrin is stored in bulk after processing packaging could continue whilst waiting for the next batch to react.

Figure 9

STARCH TO DEXTRIN



8.2.5 Potable Alcohol

Alcohol for drinking purposes or industrial uses can be made from cassava via glucose. Considerable attention is currently focussed upon alcohol or 'Gasohol' production from cassava for use in combustion engines as a fuel. At present alcohol can be more economically made from sugar cane since sugar is:

- normally produced on a plantation scale
- the waste material bagasse provides a fuel source for the alcohol fermentation process
- there is already a greater amount of fermentable sugar available in cane sugar so that little conversion needs to be undertaken from complex carbohydrates eg starch to sugar before fermentation begins.

The route from cassava to alcohol on an industrial scale is via glucose. The preparation of glucose has already been described in this report. Alcohol production is the process of converting this glucose by fermentation an distillation to alcohol. Thus a factory concept could plan for an alcohol production facility down stream from its glucose line.

8.3 Effluent Disposal

From the discussion on the processing aspects of the factory concept it can be seen that considerable quantities of water are used in the process. Where possible this is recirculated and reused. The final waste water will contain suspended solids of soil, sand and carbohydrates plus other organic matter from the process. There will also be dissolved sugars present in the water. The resultant waste is likely to have a BOD value (Biological Oxygen Demand) higher than would be permissable for discharge into local rivers and streams without some form of pretreatment.

In the tropics, especially the area around Kasama, the most convenient means of reducing the organic matter in the water is to discharge into a lagoon. This allows suspended solids to precipitate out and with high evaporation rates the bulk can also be considerably reduced. Provided the lagoon is large enough to allow a residence time of approximately one week then this method of treatment should be satisfactory. Overflow over a wier would tend to discharge relatively clean water if this residence time is allowed. Thus a lagoon for 5 days discharge of water waste from the factory would need to contain 670,000 litres of water.

9. FINANCIAL EVALUATION

It is not practicable to construct hypothetical financial evaluations of the possible projects in different countries. We show in this chapter the financial evaluation of the Zambian project.

The main points of the financial evaluation of the starch, glucose and dextrins factory are set out below, including, in 9.1.6, a sensitivity analysis. The model can be used for a very rapid re-evaluation of the project at any time. If the project proceeds, actual results can be fed into the model to provide an instant picture of their implications on the factory's financial performance.

We also made a financial evaluation of a factory making starch only and supplying this to outside manufacturers of glucose and dextrins. The results of this evaluation, showing a much lower IRR than the multi-product factory, are shown in 9.2 below.

9.1 Financial Statements

The financial evaluation of the project has been done using a computer model the print out from which is attached as Appendix 12 Reports 1-12. The model logic for individual items is described in the notes attached as Reports 1A-12A, explaining the basis on which figures have been calculated.

In overall terms the model matrix is divided into two elements. Year C shown in the first two columns represents the construction period of 18 months. Year CP1 represents cost build ups in the first 12 months of project development and construction. This compression is possible since it is assumed all initial development will be done out of equity capital and has the advantage of enabling us to show more periods in the operations phase. Year CP2 represents the final six months of installation and trial runs. Thereafter ie years P1 onwards, operational years are shown in six monthly intervals (P1 = July-December, P2 = January-June). This format enables the model to demonstrate the effect of the seasonal raw material purchasing pattern on stocks and cash flow. For the same reason it is assumed that the project will have a financial year July 1st - June 30th so that year opening coincides with the major buying season.

The overall financial performance of the project is good as shown in the following summaries.

9.1.1 Profit and Loss (Report 8)

The project achieves a profit in its first year and as sales increase generates substantial cash flows to enable it to repay all borrowed capital by the end of operational year 6 period 1.

By year 6 period 2 the project is at optimal practical volume and the half year's results show the following:-

	K'000
Sales	2,088
Less raw materials	612
Gross added value	1,476
Less other variable costs	410
Contribution	1,065
Less fixed costs	597
Profit before tax	468
Tax at 50%	210
Nett Profit	258

Thus, allowing for a reasonable retention of funds for future years, a dividend of K 150-200,000 could be declared for the half year, representing an annual dividend of 15-20% on the equity capital of K2,000,000. Such a distribution would only be possible from about year 5 onwards.

9.1.2 Balance Sheet and Capital Funding (Report 9)

The project will require initial capitalisation as follows (see Yr.C P2).

	K'000	K'000
Sources of funds		
Equity capital		2,000
Term loan capital (75% P & M)		1,800
Total funds		3,800
Application		
Fixed Assets		
Land	25	
Factory buildings	500	
Housing	250	
Plant and machinery	2,400	
Vehicles	70	3,245

	K'000	K'000
Pre-production Working Capital		
Stocks	36	
Debtors	31	
Cash in hand	194	261
Pre-production expenses		294
		3,800

NB Pre-production trial runs are expected to bring in sales equal to approximately 50% of the raw materials used.

The basis of the capitalisation is the assumption that term loan financing will be available to a maximum of 75% of the cost of plant and machinery. The remainder is to be funded from fixed capital with short term overdrafts used to fund the substantial initial working capital requirements until self generated funds are available to take over.

The project's funds flow is more than adequate to service this capital profile and the project becomes totally self financing by the end of year 6 period 1 at which time the position is as follows.

	K'000	K'000
Sources of funds		
Fixed capital		2,000
Revenue Reserves	2,104	
Less surplus cash	816	1,288
Nett capital employed		3,288
Applications of Funds		
Nett fixed assets		1,848
Current assets		
Stocks	1,003	
Debtors	482	
Cash in hand	96	
	1,581	
Less current liabilities	141	
		1,440
Total Nett Assets		3,288

NB
The cash surpluses represent additional funds flow not immediately needed in the business.

Working capital requirements are substantial and grow from an initial requirement Yr.1 P1 of K842,000 to a level K1,441,000 by Yr.5 P2 levelling off thereafter. Initially K400,000 has been financed by an overdraft facility. This represents less than 50% of the total requirement and can normally be expected to be available. The overdraft is paid off by the end of year three period 1.

Term lending of K1,800,000 is equal to 75% of the cost of plant and machinery. The moratorium is three years from disbursement in Year C period 2, and repayments, at six monthly rests, take place during the following three years. The term loan is divided between two headings to enable loans of different terms to be built into the model should this prove necessary in future.

The model takes a conservative view of capitalisation which could be reduced by using a short term overdraft on a revolving basis to fund raw material stock peaks.

9.1.3 Funds Flow Statements (Report 10)

The project sustains a surplus cash position throughout its life. Funds need to be retained to finance the relatively short term loan repayment cycle, where in certain years the annual cash flow goes into deficit.

Given this debt servicing level then distributions to risk capital will be minimal for the first five years of the project. Thereafter however good dividends can be paid. Cumulative surpluses are available sufficient for a small dividend of 5% per annum from year 2 onwards, building up from an annual cumulative surplus in Yr.2 P1 of K132,000 to one of K476,000 in Yr.4 P2.

9.1.4 Financial Ratios (Report 12)

The project's performance indicates the importance of achieving good throughput. Fixed expenses are high and this in the early stages represent 53% of sales value dropping to 29% once higher throughput is achieved. This pattern is confirmed by the percentage of profit after tax to sales and it should be noted that given the high tax level of 45% the profit percentage is almost halved once tax becomes payable.

The profit on capital employed is good, achieving a level of 20.3% in terms of gross capital employed and a very creditable 30.9% on nett capital employed. This assumes substantial internal funding and early term loan repayments which mean that risk capital has to wait a considerable period before appreciable dividends can be paid.

The high capitalisation of the project is demonstrated by the fact that once established, capital is only turned over once a year and apart from the relatively high fixed capital investment, the current ratio of 11.2 to 1 indicates the high levels of stock and retained cash holdings needed to finance the crop purchases.

The overall capitalisation is conservative in development banking terms with term loans representing initially some 50% of capital employed. Debt service is reasonable dropping substantially during the major repayment period Yrs.3 P2 - Yr.6 P1. The term loan is repaid in a relatively short period which could be extended if this became necessary.

9.1.5 Internal Rate of Return (Report 12)

The internal rate of return of the project is an overall 13.64%. This is marginally above the cost of term loan capital at 13.5% and it is this debt service burden, coupled with a high risk capital component which accounts for the difference between the fully operational return on capital employed and the overall internal rate of return.

Given the importance to peasant agriculture of opening new markets for their crops by local processing perhaps more reasonable interest rates could be considered, at levels more in line with lending to the agricultural sector rather than the industrial sector.

9.1.6 Sensitivity Analysis (Report 13)

We have calculated in the sensitivity analysis the effect on cumulative funds flow and on profit after tax of changes in volume of sales (sales factor) and selling prices (price factor). The range calculated is 0 to -15% in 5% stages.

In overall terms it will be seen that the project is much more sensitive to price fluctuations than to volume fluctuations. This is particularly marked in the schedules showing effect on cumulative cash flow. In the case of price variations a drop of five percent results in a periodic maximum cash shortfall of K126,630 whilst a drop of 10% in sales volume only shows a periodic cash shortfall of K36,070. Profits after tax are not as dramatically affected since the major cash shortfalls occur due to heavy debt servicing.

It would probably be possible to reschedule the debt service to enable the factory to continue should such adverse conditions arise as follows:

- in terms of price sensitivity a price drop of 5% could be easily accommodated by loan repayment scheduling. More than this would require a major rethink of the project.

- in terms of sales volume a drop of 10% could be easily accommodated and one of as high as 15% could possibly still yield a fundable project but investment return would be very low.

9.2 Factory for Cassava Starch Only

We have modelled the factory on the basis of the cassava factory producing and selling starch only. The basis of the model is that overall output and sales will be the same, and that capitalisation will be on a similar basis as follows:

	Multiple Product		Starch Only	
	K'000	%	K'000	%
Share Capital	2,000	52.6	1,700	58.6
Term Loan	1,800	47.4	1,200	41.4
	3,800	100.0	2,900	100.0

The marginal difference in structure is caused by rounding up figures, and gives the more conservative view of lower loan capital content. The overdraft has been retained on the same basis since this is tied to working capital which has not altered significantly. Fixed asset cost has been reduced by K900,000, the cost of the glucose and dextrin plant.

The term loan conditions and repayment has been retained on the same basis as the multiple product factory. The reports 1-12 for this option are shown in Appendix 13.

In overall terms the project's internal rate of return is reduced to 8.36%. It does not offer a very attractive proposition to risk investors and would require loan capital to be made available with longer grace periods.

9.2.1 Profit & Loss Account (Report 8)

The factory does not achieve profit break even until year 2 period 1. Subsequent profitability is at a very low level and dividends to equity capital are unlikely to be forthcoming until the 7th year of the project after all debt servicing has been completed.

9.2.2 Balance Sheets (Report 8)

The initial capitalisation of the factory at the end of the construction period is as follows:

	K'000
Sources of funds	
Equity	1,700
Term loans	1,200
	2,900

	K'000
Applications	
Fixed assets	2,345
Working capital	102
Cash	161
Pre-production expenses	292
	2,900

As set up the project has sufficient capital to start operations. Applying the same conditions, repayments are too burdensome as described in the funds flow statement comments below.

9.2.3 Funds Flow Statement (Report 10)

The factory initially has sufficient capital injections to meet its needs. However from year 2 onwards cumulative cash deficits build up to a maximum of K194,000 and are not paid off until the end of year 6.

This arises due to applying the same loan terms as the multi-product factory and the situation could be alleviated by providing longer grace periods. These will need to be of the order of six months' extra grace period on the overdraft and a full year's extra grace period on the term loan.

9.2.4 Key Financial Ratios (Report 11)

Contribution is reduced from 51% to 41%. Fixed costs as a percentage of sales are initially higher but level off at the same figure. This is due to fixed costs being reduced by the plant maintenance charges. Profit on sales is marginally lower in line with the lower contribution. Given the overall reduced profitability and cash flow all other key ratios also demonstrate a poorer performance from the starch only factory.

THE EFFECT OF RAINFALL DISTRIBUTION ON CASSAVA PRODUCTION

The key to a successful cassava processing operation is to make available the required amounts of roots of the right quality over as much of the year as possible.

In order to achieve this it is fundamentally important to understand the relationship between cassava's growth cycle and the various patterns of rainfall distribution which occur in the tropics.

Growth Cycle

Cassava requires some 9-10 months of growing conditions before root yields are maximised, and starch content has reached acceptable levels. Whereas cassava does not have a definite point at which it must be harvested as, for example, some cereals, the flexibility inherent in being able to store the crop in the ground is to a certain degree offset by a deterioration in root quality and increase in fibre contents.

Rainfall Distribution Patterns

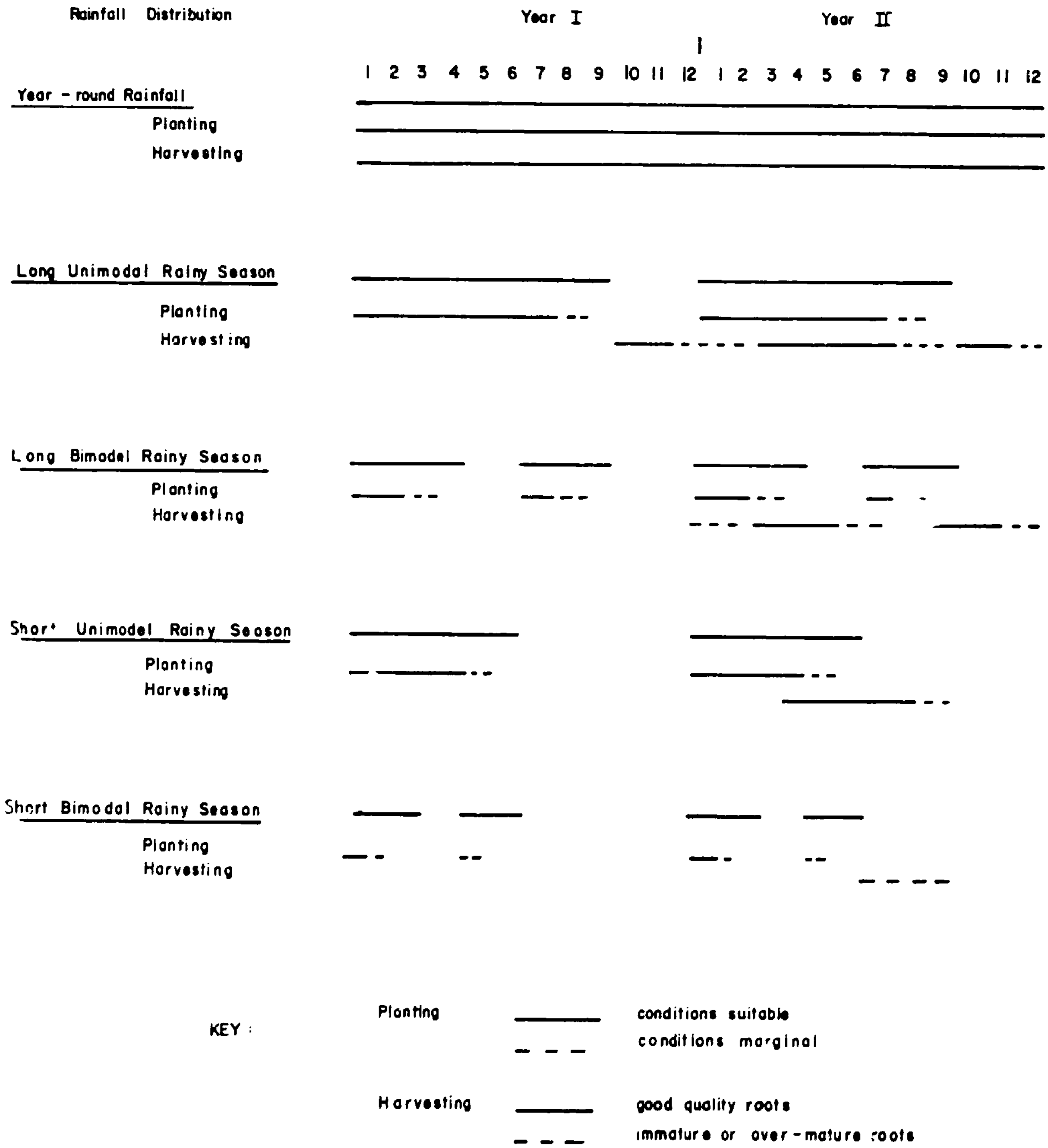
The relationships which exist between cassava production and the climate can best be described by relating the growth cycle of the crop to examples of the various patterns of rainfall distribution which occur in the tropics. Five alternatives are described:

- Year-round rainfall
- Long unimodal rainy season
- Long bimodal rainy season
- Short unidodal rainy season
- Short bimodal rainy season.

The rainfall distribution patterns are shown in Figure 1 together with the planting and harvesting operations which are feasible to undertake within these rainfall patterns. Each rainfall pattern is then described in more detail.

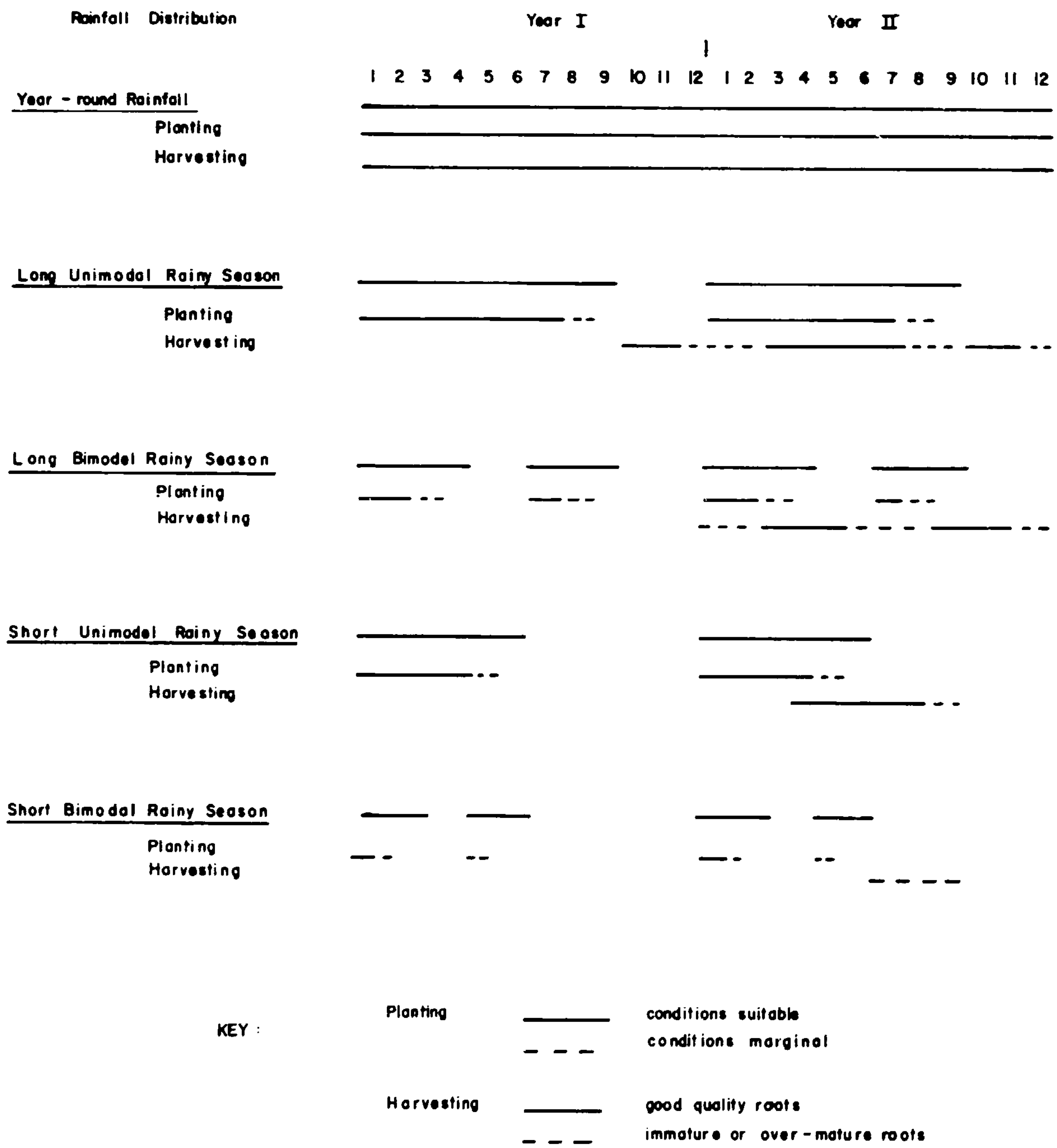
Figure 1 - Cassava Fresh Root Production

Timing of operations and availability of fresh roots as related to rainfall distribution.



Note:

The premises upon which this figure has been prepared are presented on the following page.


Rainfall Distribution
Year I
Year II
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Year - round Rainfall
Planting
Harvesting
Long Unimodal Rainy Season
Planting
Harvesting
Long Bimodal Rainy Season
Planting
Harvesting
Short Unimodal Rainy Season
Planting
Harvesting
Short Bimodal Rainy Season
Planting
Harvesting
KEY :
Planting
conditions suitable
conditions marginal
Harvesting
good quality roots
immature or over-mature roots

Premises used in the calculation of Figure 1.

1. Cassava requires 9 months of effective rain after planting to produce roots of acceptable quality for processing.

2. Cassava requires 2 months of effective rainfall after planting to establish it sufficiently to be able to withstand drought.

3. In areas where frost is likely to occur during the dry season, 3 months of effective rainfall will be required to establish the cassava and enable some reserves to be laid down.

4. It is assumed that after a long rainy season, residual soil moisture is sufficient to support growth for one month during the dry season. After a short rainy season, half a month's growth is anticipated.

5. It is assumed that harvesting after the first two months of the dry season may be difficult due to hard soil.

6. The model has been prepared on the assumption that a cassava variety which matures after nine months of growth is planted.

Year-Round Rainfall

Examples of this type of climate exist close to the Equator, namely; Peninsular Malaysia, Sumatra, Kalimantan (Indonesia), Mindanao (Philippines) and Papua New Guinea in Asia; the West African coastal strip, Congo and Zaire in Africa; and northern Brazil and the Guiana's in South America.

Year-round rainfall permits land preparation, planting, growth of the crop and harvesting to go on throughout the year. This situation is the nearest to the ideal for cassava production but is not without problems.

Periods of unremitting rainfall occur during which field operations are almost impossible due to water logged soil conditions. The operation of tractors, cultivation equipment and mechanical harvesters is not only difficult during such periods, but can be physically damaging to soil structure. Even where roots can be harvested by hand, their transportation to the factory involves tractor-drawn trailers and/or trucks which become bogged-down, cause compaction to fields and damage to farm roads. In most circumstances the harvesting of roots from waterlogged soil increases the amount of soil adhering to the roots, resulting in high soil tare and problems with the washing and disposal of soil in the processing factory.

It is realistic to expect that a cassava processing factory which relies entirely on fresh roots as its source of raw material will face many occasions during the year when fresh root supply breaks down due to wet field conditions.

Long Unimodal Rainfall Pattern

Adjacent to the areas which receive year-round rainfall are those which have one short dry season per year. This pattern of rainfall distribution permits planting to go on except during the dry season and the final months of the rainy season. However the rainfall pattern will permit harvesting to go on all year round.

Nevertheless the remarks relating to waterlogged soil in areas with year-round rainfall are equally valid for these areas.

During a dry season there are 4-5 months during which planting operations are suspended due to dry soil conditions preventing germination, or due to the danger of drought killing newly emerging plantlets. Even though sufficient area may be planted up during the early part of the rainy season to supply enough roots for the year-round operation of the processing factory, the difficulty in matching harvest date with maturity period results in the harvesting of either immature or overmature roots. This has an impact on starch recovery rate in starch factories. Where a range of varieties is available with different maturity periods ie varieties which have optimum harvest dates at 7,9, and 11 months after planting it is possible to overcome the maturity problem to a certain extent, by planting an appropriate mixture of varieties.

Long Bimodal Rainfall Pattern

Moving further away from the Equator the areas receiving a long unimodal rainfall pattern merge into those where the rainy season is broken by a dry spell. This complicates the production of cassava, since the occurrence of two dry seasons per year further limits the period during which soil moisture conditions are favourable for the planting and establishment of the crop. Only 3-5 months of planting season occur, which has a serious impact on the availability of quality fresh roots for processing. Using a standard nine-month variety, mature roots would only be available during six months of the year, even though factory operations could continue during the other six months of the yield using immature or overmature roots. Once again by planting a selection of varieties with different maturity characteristics this problem can be partially overcome.

Short Unimodal Rainfall Pattern

Areas receiving this pattern of rainfall distribution, such as Zambia, are marginal for cassava production for industrial purposes as the annual rainy season is of insufficient length to satisfy the growth requirements of the cassava crop. This makes the production of a crop of cassava, from planting to harvesting within one year very difficult. Areas receiving 6-7 months of effective rain are marginal for the production of cassava for processing purposes. In areas with a unimodal rainfall pattern with less than 6 months of rainfall there is insufficient moisture to complete the growth cycle within the calendar year and it becomes necessary to leave the crop to survive the dry season and grow on through the rainy season of the following year. Although harvesting after one rainy season is practised by some farmers, both the yield and starch content of the roots are depressed through the crop being harvested prematurely.

From the processors' point of view the production of cassava in such areas is far from ideal. The crop has to occupy the land for two years before yields of roots with satisfactory starch content are available. Also, due to difficulties of harvesting roots from dry soil, the harvesting operations are hindered and may be eventually stopped by hard soil conditions after the residual moisture from the rainy season has gone from the soil. This factor varies with the physical properties of the soil. Nevertheless, because of the short planting period (4-5 months) and the long dry season, it is impossible to organise the production of roots of processing quality for more than 5 months of the year and there are 6 months of the year when it is difficult to obtain roots of even marginal quality.

Cassava processing factories set up in areas with this type of rainfall distribution can expect to experience fresh root supply problems for extended periods, especially during the last part of the dry season and the first part of the rainy season.

This is the reason for basing the Zambia factory project on dried cassava chips, rather than roots, as the major raw material for starch.

Short Bimodal Rainy Season

Much of the sub-Sahel region and Southern Africa fall into this rainfall distribution belt. There is insufficient rainfall to produce a crop of roots of processing quality, even when the crop is grown over a two year period to include four rainy seasons (two per year). The resulting crop is then only available for a short period each year.

Because of the two short rainy seasons followed by a long dry season the planting of the cassava crop must be carried out with the first rains of the first rainy season to ensure its establishment before it experiences the rigours of drought. The impact of this restricted planting season is the difficulty in spreading the period of availability of mature roots over an extended period.

Availability of fresh roots for processing related to rainfall distrubution (months/year)

	Good Quality Roots	Poor Quality Roots	Total
Year round rainfall	12	-	12
Long unimodal rainy season	7	5	12
Long bimodal rainy season	6	6	12
Short unimodal rainy season	5	1	6
Short bimodal rainy season	-	3	3

Thus roots for processing are very limited both in quantity and quality for much of the year.

The establishment of a processing industry based on the supply of fresh cassava roots must be regarded as extremely marginal in areas with this rainfall distribution.

The periods of fresh root availability for the different rainfall distribution patterns are shown above.

Cassava Production under Irrigation

The previous discussion has dealt with the problems associated with fitting cassava productionfor processing into natural patterns of rainfall distribution. An alternative is the modification of the environment by irrigating during dry periods. Inthis way it is technically feasible to produce cassava throughout most of the year. However it is a question of economics, and there are few - if any - circumstances where the cost of the provision of irrigation facilities can be borne by such a low value crop as cassava.

Nevertheless there are circumstances when cassava can be grown under irrigation which are economically justifiable. Such a circumstance exists when surplus water from an existing irrigation scheme is available from time to time during the year. It is often possible to predict the periods during which surplus water is available, and plantings of cassava can be timed to coincide with these periods. Therefore by using natural rainfall supplemented by periods of irrigation it is possible to extend the planting period and therefore the production period over much of the year.

This opportunity is particularly worthwhile in areas where the topography is level, allowing the application of water by surface flooding techniques. These do not involve heavy infrastructure costs, so making it economically more attractive. The costs of irrigation are therefore composed basically of water costs and the cost of providing earth channels to direct the water on to the crop.

This opportunity of using cassava to "mop-up" surplus water from existing irrigation schemes is particularly valid for ethanol factories, where a mix of sugar cane and cassava are used as fermentables.

The lack of a critical period such as flowering, coupled with a degree of drought tolerance make cassava an ideal candidate to mop up surplus water, as providing the crop is established there is no necessity to have water available at critical times and periods without irrigation will not cause the total loss of the crop.

COSTS OF PRODUCING CASSAVA

It has been shown in Chapter 5 that cassava production is tied in with the rainfall distribution pattern and a range of production alternatives occurs. The extremes are continuous production of cassava with all the various field operations underway at all times; and a specific, restricted period of the year during which certain operations, such as planting, must be carried out.

There is no simple formula for calculating labour, machinery and material inputs on a global scale. Each producer must decide which production system is most relevant to his circumstances and build up the economics of production using the various inputs on a piecemeal basis. The following table provides estimates of labour inputs for various operations involved in cassava production.

Labour Inputs in Cassava Production

	Man Days/ha
Planting by hand	9.0
Fertiliser application by hand	4.0
Replacing missing plants	1.5
Weed control (3 rounds)	30.0
Selection of planting material for next crop	3.0
Removal of tops before harvest	9.0
Lifting root clumps	10.3
Removal of trimming roots	9.0
Loading	1.5
Total	77-78

Transportation of planting material to the field and preparation of cuttings must also be catered for. The time needed for these operations will vary widely in different locations and circumstances.

No land preparation figures are included in the above table as this would in most cases be done by hired tractor.

In addition to the above list of operations material inputs are required at all levels of cassava production. At the most primitive hand tools are required in the form of knives for preparation of planting material, clearing tops before harvesting and trimming roots, and hoes for soil preparation, weeding and harvesting. Where cash is available for the full range of material inputs required to maximise yields the following additional list is relevant;

- insecticide/fungicide treatment for cuttings
- fertilisers
- herbicides, both pre-emergence & post emergence
- crop protection sprays (rarely justifiable)
- machinery and equipment for a range of operations.

During the early years of establishing a cassava production unit, the purchase of planting material is usually necessary. In areas where only small amounts are available this may involve quite a substantial financial provision.

Transportation of fresh roots from field to factory.

This subject is of vital importance in the context of cassava processing. The economics of transporting a low value, bulky crop such as cassava must be carefully calculated before selecting a production area and siting a factory. The difficulties in transporting roots along un-made roads during wet periods are discussed elsewhere. The selection of the type of transport equipment, comparing fast-moving lorries which can easily become stuck during periods of wet weather, to slow moving tractors and trailers must be carefully made. Provision of sufficient equipment to satisfy both field operations and transport requirements is stressed, particularly in tractor numbers. The distance between the production area and the factory involves not only increased fuel and equipment running costs, but also may require additional units of equipment due to protracted running time.

MECHANISED CASSAVA PRODUCTION

Traditionally cassava has been a crop grown on a small scale under labour intensive, small farmer conditions. It is only in comparatively recent times that interest in cassava for processing on a large scale has lead to its development as a plantation crop.

Mechanisation of cassava production is therefore in its early stages; many large plantations are still heavily dependent on manual labour for such operations as planting, weeding and harvesting.

Machinery is now available to plant cassava and to bring the tubers to the surface at harvest time, but no automatic planter or full system harvester has yet been developed. Consequently there is a labour requirement in both of the mechanised operations. Land preparation and chemical weed control systems have been adapted from existing and developing technology.

Machinery requirements for mechanised cassava production can be classified into two groups:

1. Those which are cassava specific.
2. Those which have an application in the culture of other crops in the rotation.

Equipment falling into group one would be:

a) Ridger (may have application with break crops)
b) Cassava planter - multi-row
c) Cassava stem pulveriser
d) Cassava digger/lifter
e) Cassava tuber bulk handling facilities.

Equipment in group two would be:

a) Subsoiler or chisel ripping plough
b) Plough or disc ploughing harrow
c) Field crop sprayer
d) Fertiliser distributor
e) Tipping trailers.

Tractors would of course be required as prime movers for the equipment.

There would be also a need for equipment for estate maintenance eg grader, grass cutter, loader for gravel and perhaps a ditcher.

Break crop specific equipment such as planters, combine harvesters may be required but are not considered here as they would be costed against the applicable enterprise.

Five areas have been classified according to rainfall distribution.

Areas of year round rainfall, areas where there is a long unimodal rainy season and areas which have a long bimodal rainy season are capable of production for a sufficient period each year to warrant mechanisation of the crop.

Climatic areas with short unimodal rainy seasons and short bimodal rainy seasons are generally not suitable for large scale cassava plantations, and it is unlikely that cassava enterprises in such areas could support mechanisation costs.

Mechanisation requirements for plantations in areas one to three are discussed below. The choice of break crop to be grown will affect the need for machinery. No allowance has been made for break crop specific equipment.

Root Production - Under Year Round Rainfall Conditions

For agronomic reasons continuous cassava culture is not recommended and a rotation which embodies principles of good husbandry should be selected. Cassava yields tend to diminish in the third successive crop, therefore the rotation would probably be two years cassava and one or two years break crop depending on the choice of crop.

To provide raw material (cassava tubers) for processing at the rate of 40 tonnes per day for 280 days per year under year round rainfall conditions an area of approximately 622 ha of cassava would be necessary if one assumes a yield of 18 tonnes/ha.

For a one year break crop rotation, an estate of approximately 933 ha would be required, and 1,244 ha would be required if the two year cassava, two year break crop were to be selected. The areas quoted are net cultivable land, total estate area including roads, drains, firebreaks, unusable land and buildings would be 15-20 percent more.

It is assumed that land clearing has been carried out to leave the land in a suitable condition for mechanised operations, ie free of stumps and obstructions.

Land preparation operations are influenced by soil type and condition, therefore local conditions may make it necessary to modify the number and type of operations suggested here.

Under year round rainfall conditions there maybe a considerable loss of working days due to wet field conditions. Machinery capacity must therefore be increased by 20 percent to allow flexibility and to even out raw material supply.

This surplus capacity can be used to plant only under suitable conditions, and to harvest roots in addition to those required for input at the factory. The additional roots may be chipped, sun dried and then stored until required to keep the factory running on days when fresh roots are not available.

Field Operations

1. a. Chisel plough
   b. Cross Chisel plough if necessary

2. a. Disc Ploughing Harrow pass
   b. Second disc ploughing harrow pass if necessary

3. Fertiliser application
4. Ridge
5. Plant
6. Herbicide spray/hand weed
7. Herbicide spray/hand weed
8. Hand weed if necessary
9. Pulverise stems
10. Harvest
11. Transport.

Year Round Rainfall

Machinery Requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	1	575	575
Ridger	1	730	730
Planter	2	1,750	3,500
Crop sprayer	1	1,440	1,440
Knapsack sprayers	10	40	400
Cassava stem pulveriser	1	4,000	4,000
Cassava harvester	3	2,800	8,400
Loader handler	1	2,200	2,200
Boxes	100	18	1,800
Trailers - 8 tonne tandem axle	3	1,800	5,400
Water tanker	1	3,500	3,500
Tractors, 78 hp 4 x 4	6	10,500	63,000
Tractors, 78 hp 2 wheel drive	3	8,500	25,500
	Total		131,345

Machinery capital cost = £211.17 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities which must be provided.

Long Bimodal Rainfall System

It is assumed that yields achievable under long bimodal rainfall conditions are approximately 12 tonnes/ha in Africa.

934 ha of cassava would be necessary to produce sufficient fresh roots to supply a factory with the equivalent of 40 tonnes of fresh roots per day.

Quality roots can be harvested for only 6 months of the year so equipment specified is capable of harvesting the total area in 6 months. Roots surplus to requirements would be sun dried and used to provide raw material for the factory during the rest of the year.

Long Bimodal Rainfall System

Machinery requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	2	575	1,150
Ridger	4	730	2,920
Planter	10	1,750	17,500
Crop sprayer	1	1,440	1,440
Knapsack sprayers	15	40	600
Stem pulveriser	3	4,000	12,000
Cassava harvester	7	2,800	19,600
Loader/handler	2	2,200	4,400
Boxes	200	18	3,600
Trailers	4	1,800	7,200
Water tanker	1	3,500	3,500
Tractors 78 hp 4 x 4	18	10,500	189,000
Tractors 78 hp 2 wheel drive	2	8,500	17,000
	Total		290,810

Machinery capital cost = £311.36 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities to be provided.

Long Unimodal Rainfall

It is assumed that yields under long unimodal rainfall patterns will be similar to those achieved under year round rainfall.

Due to constraints on operations imposed by the rainfall pattern, less time is available for the various operations and good quality roots will probably be available for only 7 months each year.

The equipment list provides for the harvest of all roots during the seven month period. Roots surplus to the factory daily requirement would be chipped and dried to provide raw material for the factory for the remainder of the year.

Long Unimodal Rainfall

Machinery requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	1	575	575
Ridger	2	730	1,460
Planter	3	1,750	3,500
Crop sprayer	1	1,440	1,440
Knapsack sprayers	10	40	400
Stem pulveriser	2	4,000	8,000
Cassava harvester	4	2,800	11,200
Loader handler	2	2,200	4,400
Boxes	100	18	1,800
Trailers - 8 tonne tandem axle	4	1,800	7,200
Water tanker	1	3,500	3,500
Tractors 78 hp 4 x 4	14	10,500	147,000
Tractors 78 hp 2 wheel drive	5	8,500	42,500
	Total		243,875

Machinery capital cost = £392.09 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities to be provided.

CHIP DESIGN AND QUALITY

The fundamental food processing concept, that quality of product is directly related to the quality of raw material, is especially true of cassava processing. The finest quality starches can only be made from fresh roots which are harvested and processed at a time and in a manner controlled and directed by the factory. A sun dried cassava chip of unknown origin and age is inevitably going to result in starch of poorer quality. The factory which relies on the supply of dried chips as its raw material will therefore be most concerned that its supply is of the highest quality possible. This will be inherently difficult if the supply is from smallholders and is reliant upon the weather. The factory's main criteria for buying chips will be that they are:

- thoroughly dry
- free from foreign matter (sand, dirt, insects)
- free from mould or bacterial deterioration
- white in colour
- derived from plants of the right maturity.

Chip Design and Drying

To ensure that a chip is dried in the shortest possible time by the natural means of sun and wind, the geometry of the chips must allow the maximum exposure to these drying forces. A large section of root which is exposed to sun drying will quickly dry on the outside but will seldom become dry through to the centre before deterioration from micro-organisms has taken place. This deterioration will not take place if the moisture content is below 12 percent moisture, ie below the level to support the micro-organisms. Therefore the size of the chip is important to ensure thorough drying - the smaller the better since this will dry throughout far quicker. On the other hand if a chip is too small, not only will it be blown away or crumble into a dust but it will also be more likely to become mixed with dust, soil or sand.

The vectors which cause drying are wind and sun. The wind is possibly the more important of the two. In order to increase the effect of these vectors several factors need to be considered:

- geometry of chip, ie shape and size
- loading depth, ie depth of pile exposed for drying
- air temperature
- windspeed
- solar radiation
- moisture content of the fresh root.

The recommended geometry of the chip is 5mm wide by 50-80mm long. These can be made from simple chipping machines which chop the root. The machines are often made in the country from locally available materials.

The loading depth is important if the sun and wind are to reach each chip. The maximum depth recommended is 10kg/sq. metre. This density will vary depending on whether the chips are being dried on trays or on the ground.

Air temperature and windspeed are factors which ensure that the air surrounding the chip is dry enough to evaporate moisture from the chip surface. The effect of drying is considerably increased if the chip is raised off the ground to allow air circulation around it. The system in Zambia of woven matting held off the ground is effective and should be encouraged. In some countries inclined trays are used which angle the chips towards the sun, thereby increasing solar radiation and increasing the effect of the wind. These are often expensive to erect and have been mainly used for experimental purposes. If trays or woven mats can be easily and cheaply made locally then considerable increases in drying can be achieved. The quicker the drying the less deterioration can occur with the quality of chip.

PROPERTIES AND USES OF GLUCOSE SYRUPS

Type glucose	Properties	Use
Acid-converted	High viscosity, moderately sweet	This is the original 'glucose'. It is limited in its properties (43 because the composition is predetermined by the degree of hydrolysis. Used in sugar confectionary, mixed syrups, and chewing gum.
Acid-enzyme dual (63 DE)	Increased moisture holding, higher sweetness, less flavour masking, higher fermentability, and lower viscosity.	This was the first technological breakthrough in glucose production. Suostituted for acid-converted glucose at higher levels Has taken over most of the market in preserves, catsup, fruits, marshmallows, bar candy, etc. because of better humectant properties and increased sweetness. Also because of higher fermentability, widely used in brewing.
High maltose (43 DE)	Controlled moisture absorption in candy. Low dextrose content reduces danger of crystallisation. Improved colour stability and taste.	The first product in a proliferation of new glucose products starting about 1959. This and subsequent products were obtained by manipulation of the carbohydrate composition by use of specific enzyme systems. Used primarily for hard candy at increased levels up to 50% DE. In jams and jellies, can use at maximum allowed by the US Food and Drugs Administration plus added dextrose. In ice cream, can be used at higher levels up to about 40%.
High fermentable (70 DE)	Increased percentage of fermentable sugars up to 80% plus.	Will replace up to 100% of sugars in bread and rolls. First syrup to be widely accepted by the baking industry.
Acid-enzyme Extra high DE (70-72 DE)	Increased sweetness, reduced content of high sugars, less flavour masking, reduced viscosity.	Replaces conventional "Dual" in fruit juices and concentrates. Possible future application in canned fruits and pickles.
Liquid glucose (95 DE)	Contains 80-90% dextrose plus higher sugars. Can be considered commercial liquid dextrose.	Used in pickles, although limited by relatively low solids. Used in baking to replace crystalline dextrose.
High maltose Extra high DE (52 DE)	Increased maltose content. Reduced hygroscopicity in sugar boilings.	Can be used in ice cream at levels to 50%. Used in confectionery, especially hard types, at higher levels.
High maltose Low DE (36 DE)	Reduced humectant properties. Increased viscosity and body.	Not available at present. Indicated use in dried cream substitutes. Possible use in ice cream and dried juice powders.

SOURCE: STARCH PRODUCTION TECHNOLOGY. Radley 1976.

PESTS AND DISEASES OF CASSAVA IN ZAMBIA

INTRODUCTION

Although a countrywide survey of the pest and disease situation has not been carried out, sufficient circumstantial evidence is available through reports and observation to suggest that a number of serious pests and diseases are present in Zambia. These must be seen to be responsible for significant yield losses and pose a serious threat to increased production. A better understanding of pests and diseases by the extension services could lead to an improvement of the current situation.

PESTS

The protracted dry season renders cassava prone to insect pests which thrive under dry conditions. A number of these colonise the cassava to draw their food requirements from the plant.

Scale Insects

Severe infestations by this pest were observed during the consultants' visit to Zambia, particularly at Misamfu Research Station, Kasama, in Northern Province. The insects resembled **Aonidomytilus albus** but proper identification should be carried out by a competent entomologist.

Heavy scale populations cover the stem and lateral buds. Sucking activities weaken the plant, cause defoliation and death to the stem apex, and may even kill young plants. Although wind dispersal is known to occur the pest is usually transmitted from crop to crop on infested cuttings. The scale population increases during dry periods: therefore crops of cassava planted late in the rainy season, thereby entering the dry season in an immature stage of development, are particularly prone to severe damage.

Some natural parasitism of the scale occurs, particularly by the coccinellid **Chilocorus distigma.** Avoidance of infested plants for use as planting material is the best method available to subsistence farmers. Applications of systemic insecticides to plants which will be used for planting material is recommended for those situations where cash is available. As a last resort, infested cuttings can be dipped in insecticide but even after killing the scales, the performance of the cutting may be poor.

Mealybugs. This important pest has been reported in Northern Zambia and again is favoured by the dry season. High mealybug infestations are reported to cause severe problems to the cassava plant. Initially attacking the terminal area of the shoots, the insects invade older parts of the shoot, petioles and leaves when population pressure becomes severe. The damage to the plant is done in two ways; by sucking sap and by introducing an unidentified substance into the plant during sap-sucking which causes stunting of the shoot. Heavy populations result in gross distortion of the shoot apex, die-back and in severe cases death of the plant. The causative organism **Phenacoccus Manioti** is believed to have been introduced to Africa from S. America.

The insect pest is dispersed on infested planting material or by wind. Control by chemical methods through the dipping of cuttings is the only sure method of combatting the pest. No natural predators are known which are effective at low-level mealybug populations. Farmers can reduce potential damage by the pest by planting early in the rainy season to ensure that the crop is well established and thus better equipped to withstand an attack during the dry season.

Termites. These insect pests attack cuttings, young plants and even root-tubers in extreme cases. The severity of the attack is related to the length of the drought, and plants established late in the rainy season are particularly prone to attack. Wilted shoots and dead plants are the symptoms of termite attack. The tubers of apparently healthy plants may be found to have been hollowed out by termites on harvesting. Very high losses are reported when cuttings are planted into termite infested soils during dry periods. Insecticide treatment to cuttings by dipping or dusting has been shown to be an effective method of protection.

Whiteflies. Although not considered to be an economic pest of cassava per se, the whitefly **Bemisia tabaci** (and other **Bemisia spp**) have been observed on cassava in Zambia. The importance of this pest is related to its suggested role as vector of African Mosaic Disease.

DISEASES

Cassava Mosaic Disease. This is the major disease of cassava in Africa and is endemic throughout the continent, Zambia included. Believed to be caused by a virus (or a complex of viruses) transmitted by the whitefly **(Bemisia** spp), the disease causes considerable losses. Depending on the severity of infection the symptoms vary from mild yellowish mottling of leaves to severe leaf distortion and yellow areas. Leaves are reduced in size by severe infections and root yields may be reduced by as much as 80 percent depending on the cultivar grown. Differing degrees of resistance to the disease are known, and the use of those showing high degrees of resistance is a recommended method of combatting the disease. Recent research indicates that roguing infected plants may hold promise as a means of preventing the serious build-up of the disease in clean plantations.

Cassava Bacterial Blight. This disease is reported in the Northern Province and is caused by **Xanthomonas Manihotis.** The organism causes water-soaked angular spots on leaves which may develop into more serious symptons including blight, wilt, defoliation and stem die-back. Exudation of gum from leaf veins, petioles and immature stem may also occur. As the disease is caused by a vascular pathogen, it can move throughout the plant even to the roots. Similarly the disease is passed from year to year by the use of infected planting material cut from plants with the disease. Infection from diseased plants to healthy plants within a crop is by rain splash or on contaminated hand tools, clothing etc. Varieties showing high levels of resistance to the disease are known and are recommended in countries where available. Cuttings from healthy plants should be used as planting material where possible.

Methods are available for the production of disease-free cuttings from diseased plants, and can be used where otherwise healthy material is not available.*

FROST DAMAGE

Although frosts are predictable during most years in many parts of Zambia, especially the Central and Southern Plateau areas, occasional frosts may occur all over the country. Mild frost affects cassava by causing bronzing of the leaves. As the severity of the frost increases its effects on the plant increase from leaf scorch, defoliation, stem-tip, die-back, to total death of above-ground parts of the plant. Providing the soil does not freeze the cassava plant will survive air frosts of -10°C. Even though all the above-ground parts of the plant will be killed, growth is resumed from buds on the stem base or planting piece below soil level.

Frosted cassava which has been defoliated and the green-portions of the stem killed resemble those severely attacked by cassava bacterial blight or **Phoma** spp. Some reports of these diseases in Zambia may have been caused by frost.

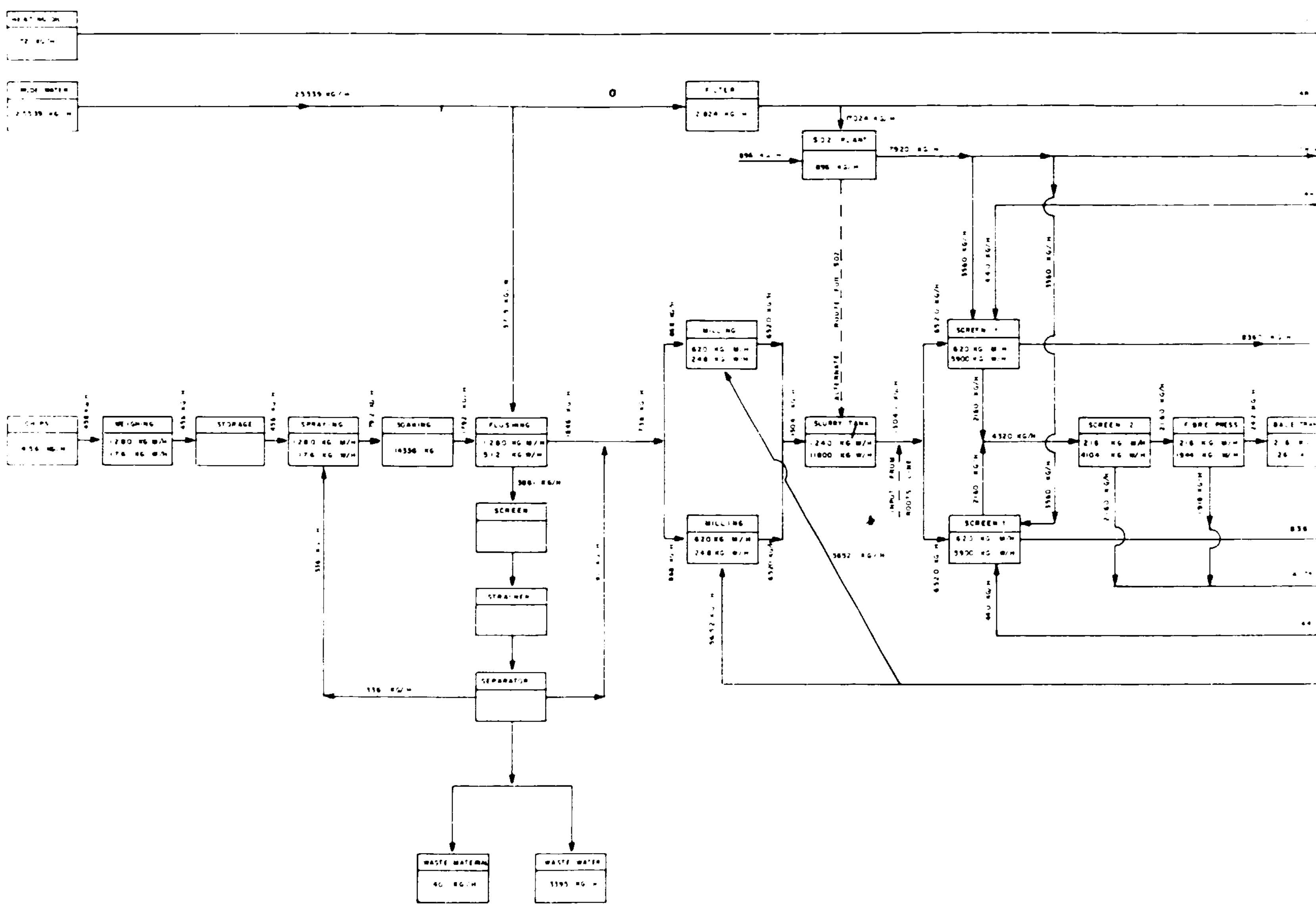
OTHER PESTS AND DISEASES

Pests and diseases other than those described above may occur in Zambia, but no reports are available.

They may occur in neighbouring countries and can be expected to spread into Zambia. One such example is the pest 'green spider mite'. This pest was introduced by accident from the Americas to Uganda and is spreading to many parts of Central West and East Africa. The mite is particularly severe in areas with long dry seasons and its activities in the growing point and developing leaves at the stem apex, cause a severe reduction in leaf size. This results in poorer yields. The Zambian authorities should be on the lookout for the appearance of this pest.

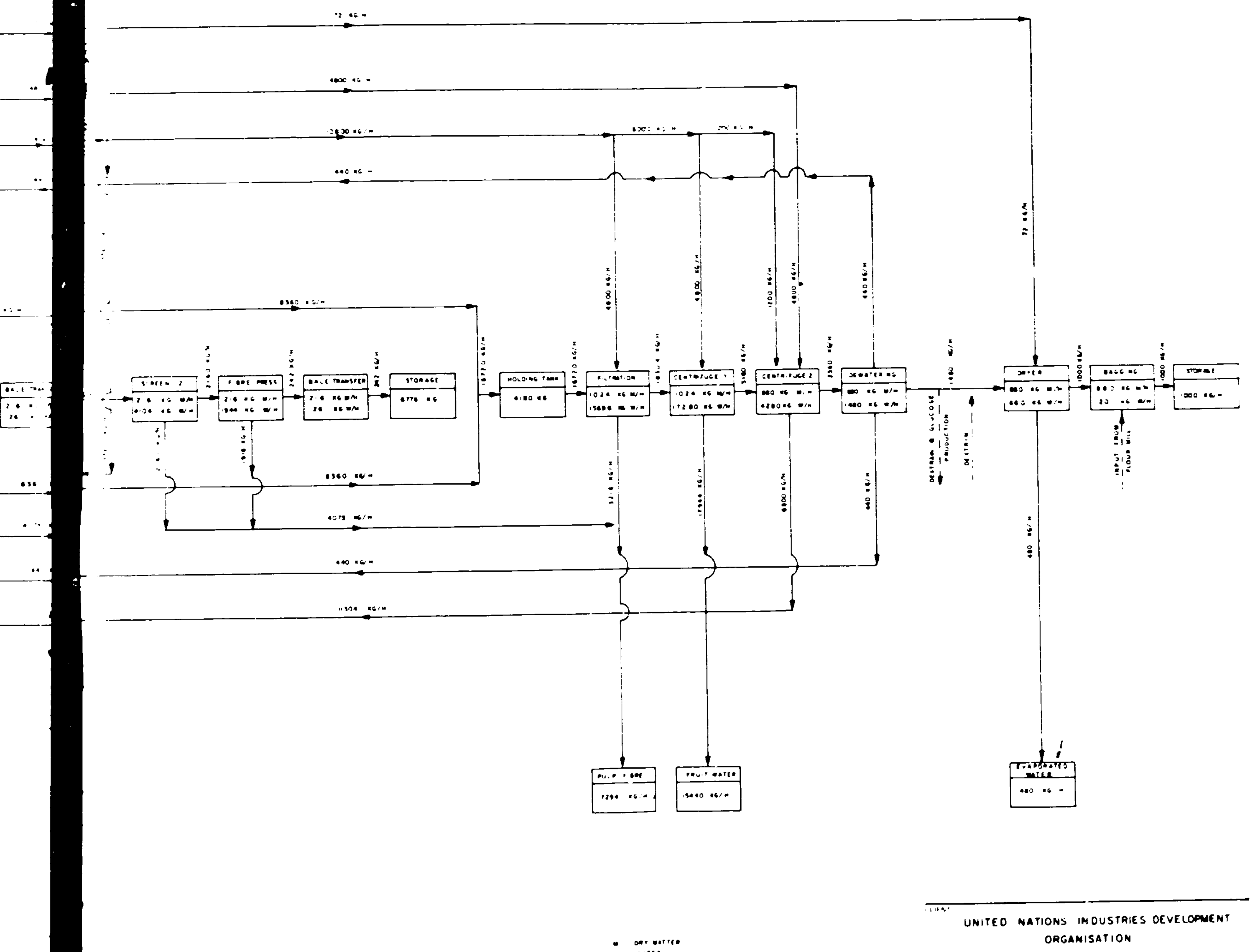
***Footnote:**

Ref: 'The International Exchange and Testing of Cassava Germ Plasma in Africa' edited Eugene Terry & Reginald Macintyre; pub'd 1975 by International Development Research Centre.


SO2 PLANT
SLURRY TANK
SCREEN 2
FIBRE PRESS
SCREEN
STRAINER
SEPARATOR
FLUSHING
SOAKING
STORAGE
WEIGHING
SPRAYING
MILLING
FILTER
WASTE MATERIAL
WASTE WATER

SECTION 1

APPENDIX 8

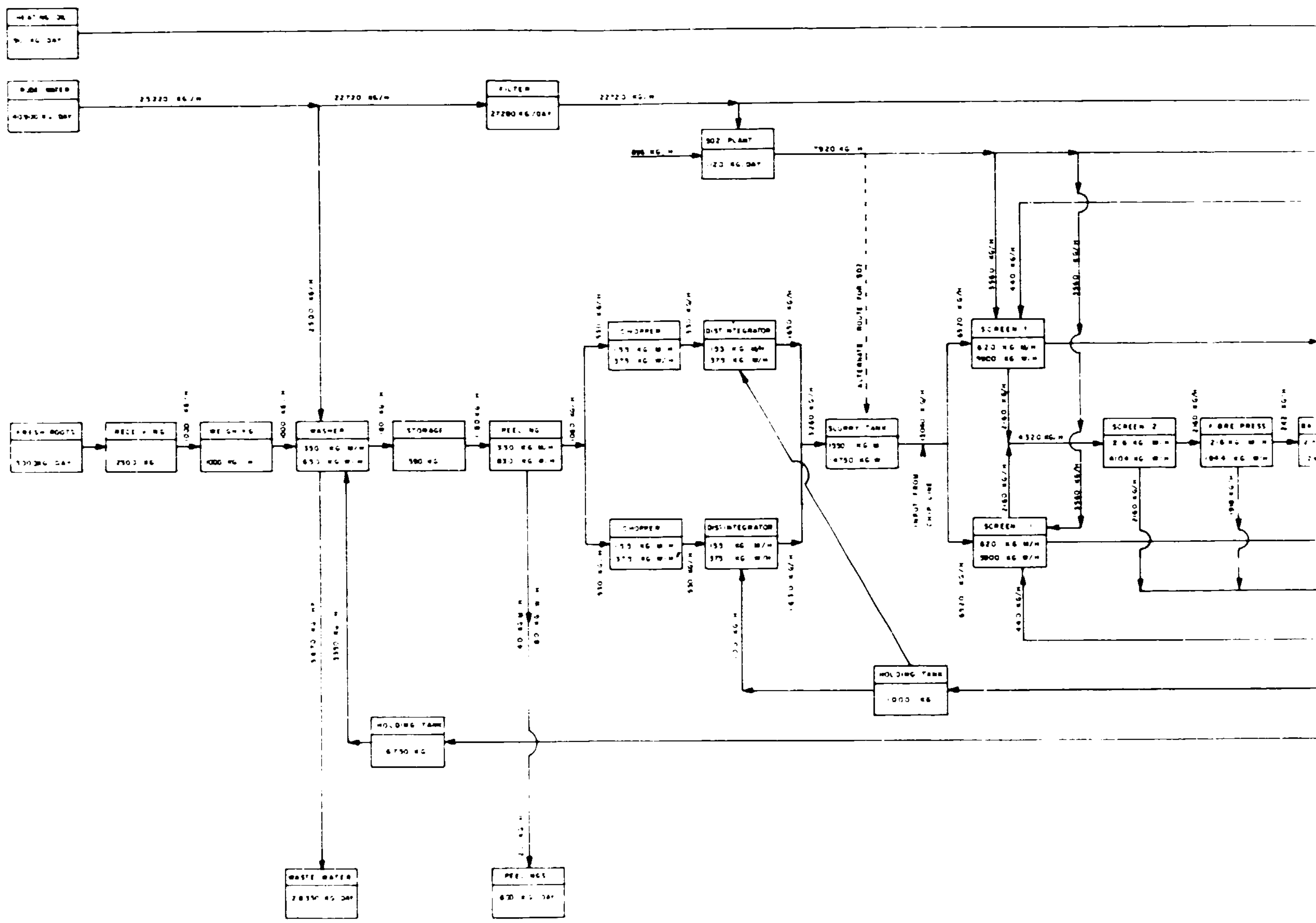


UNITED NATIONS INDUSTRIES DEVELOPMENT ORGANISATION

TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM CHIPS

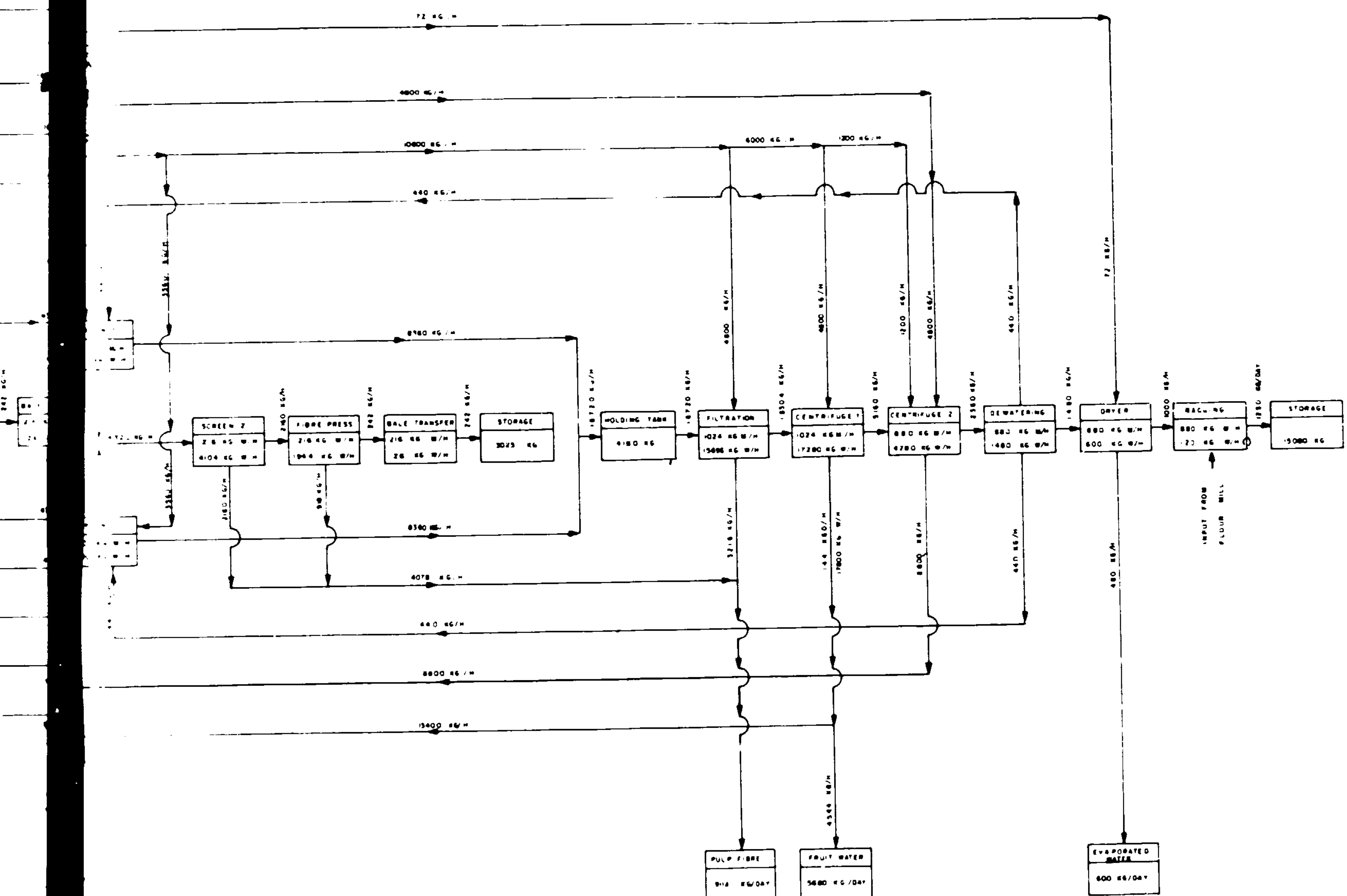
SCALE —	DRAWN R W W	DATE MARCH 82
JOB 0290851	DRAWING 2	REVISION

SECTION 2


FILTER
SO2 PLANT
WASHER
STORAGE
CHOPPER
DISINTEGRATOR
SLURRY TANK
SCREEN 1
SCREEN 2
FIBRE PRESS
HOLDING TANK
WASTE WATER

SECTION 1

APPENDIX 7



■ DRY MATTER

▼ WATER

THROUGHPUT BASED ON ROOT INPUT OVER 5HRS AND CONVERSION AFTER SLURRY TANK IN 1/4 HRS TO GIVE STARCH OUTPUT OF 1 TONNE/HR

CLIENT	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION
TITLE	TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM ROOTS

SCALE	DRAWN RWW	DATE MARCH 82
JOB 0290851	DRAWING	REVISION

SECTION 2

LIST OF MACHINERY REQUIRED FOR PROPOSED FACTORY

A. STARCH EXTRACTION - Fresh Roots and Chips

2 x Conveyor/Elevator
1 x Washer
2 x Chopper
2 x Rasping Machine
2 x Elevator
2 x Hopper
2 x Dosage Screw
1 x Disintegrator
1 x Pump
2 x Slurry Tank with paddle
1 x Starch Separator
1 x Pump
1 x Starch Separator
1 x Cyclone for sand extraction
1 x Separator
1 x Pump
1 x Separator
1 x Pump
1 x Vacuum Filter with feed tank
1 x Screw conveyor
1 x Flash drier
1 x Screen/Sieve
1 x Starch Bulk Silo
1 x Bagging Machine
1 x Sewing Machine
1 x Conveyor

B. GLUCOSE PRODUCTION

1 x Pump

1 x Balance Tank/Starch Suspension Tank

1 x Acid Tank

1 x Vacuum Filter with feed tank

1 x Pump

1 x Water Tank

1 x Flow Meter

1 x Pump

1 x Water Heater

1 x Plate Heat Exchanger

1 x Centrifugal Heat Exchanger

1 x Monopump and Filter

1 x Temperature Recorder

1 x Plate Heat Exchanger (cooler)

1 x Expansion Chamber

1 x pH Meter

1 x Caustic Tank

1 x Pump

1 x Filter/Clarifier

1 x Holding Tank

1 x Filling Machine

1 x Drum Filling & Weighing Machine

C. DEXTRIN PRODUCTION

1 x Conveyor Elevator
1 x Reactor Vessel
1 x Pump
1 x Acid Tank
1 x Pump
1 x Water
1 x Conveyor
1 x Sifter
1 x Conveyor
1 x Bulk Store/Bin
1 x Bagging Machine
1 x Sack Sewing

D. UTILITIES REQUIRED

1 x Boiler
1 x Sulphur Dioxide Plant
1 x Hydrochloric Acid Plant
1 x Caustic Soda Mixing Plant
1 x Effluent Treatment Plant (Civil engineering)
Process Piping
Process Control Systems
Utility Piping
Electrical Works and Cable
Building Materials
Spare parts, workshop and store.

APPENDIX 10

1. DETAILS OF MACHINERY MANUFACTURERS ABLE TO PROVIDE TURNKEY FACTORIES

	NAME & ADDRESS OF COMPANY	COMMENTS
1.	ALFA LAVAL AB POSTFACK S14700 TUMBA, SWEDEN	Complete starch plants from cassava using centrifugal process. Fresh roots to starch only.
2.	HOVEX ENGINEERING LIMITED AE - KADE 35a P O BOX 105 VEENDAM, HOLLAND	Complete engineering design and installation of starch factories.
3.	KOMATSUGAWA CHEMICAL ENGINEERING COMPANY LIMITED 5F TMM BUILDING NO. 10-5, 1-CHOME IWAMOTO-CHO CHIYODA-KU TOKYO,101, JAPAN	Consulting engineering and project preparation.
4.	NIVOBA POSTBUS 40 9640 VEENDAM, HOLLAND	Compact containerised starch plants. Considerable experience of cassava processing especially from dried chips. Also glucose and dextrin plants.
5.	NEWELL DUNFORD ENGINEERING LTD NEWELL DUNFORD HOUSE PORTSMOUTH ROAD SURBITON SURREY UK	Complete gari manufacturing plants on turnkey basis. Little experience of starch production.
6.	PROJECTS DEVELOPMENT INSTITUTE (PRODA) 3 INDEPENDENCE LAYOUT P O BOX 609 ENUGU, NIGERIA	Design and fabrication of equipment for processing raw cassava into gari.
7.	SALZGITTER INDUSTRIEBAU GmbH POSTFACH 411169 3320 SALZGITTER 41 F R GERMANY	Complete starch glucose and dextrin plants from fresh cassava.
8.	STARCOSA GmbH POSTFACH 5105 AM ALLEN BALMHOF 5 D 3300 BRAUNSCHWEIG F R GERMANY	Cassava flour plants and complete starch plants.
9.	UBERSEE-TECHNIK RODINGSMARKT 29 2000 HAMBURG 11 F R GERMANY	Planning and erection of industrial plant, specialising in equipment for the production of starch, and starch derivatives.

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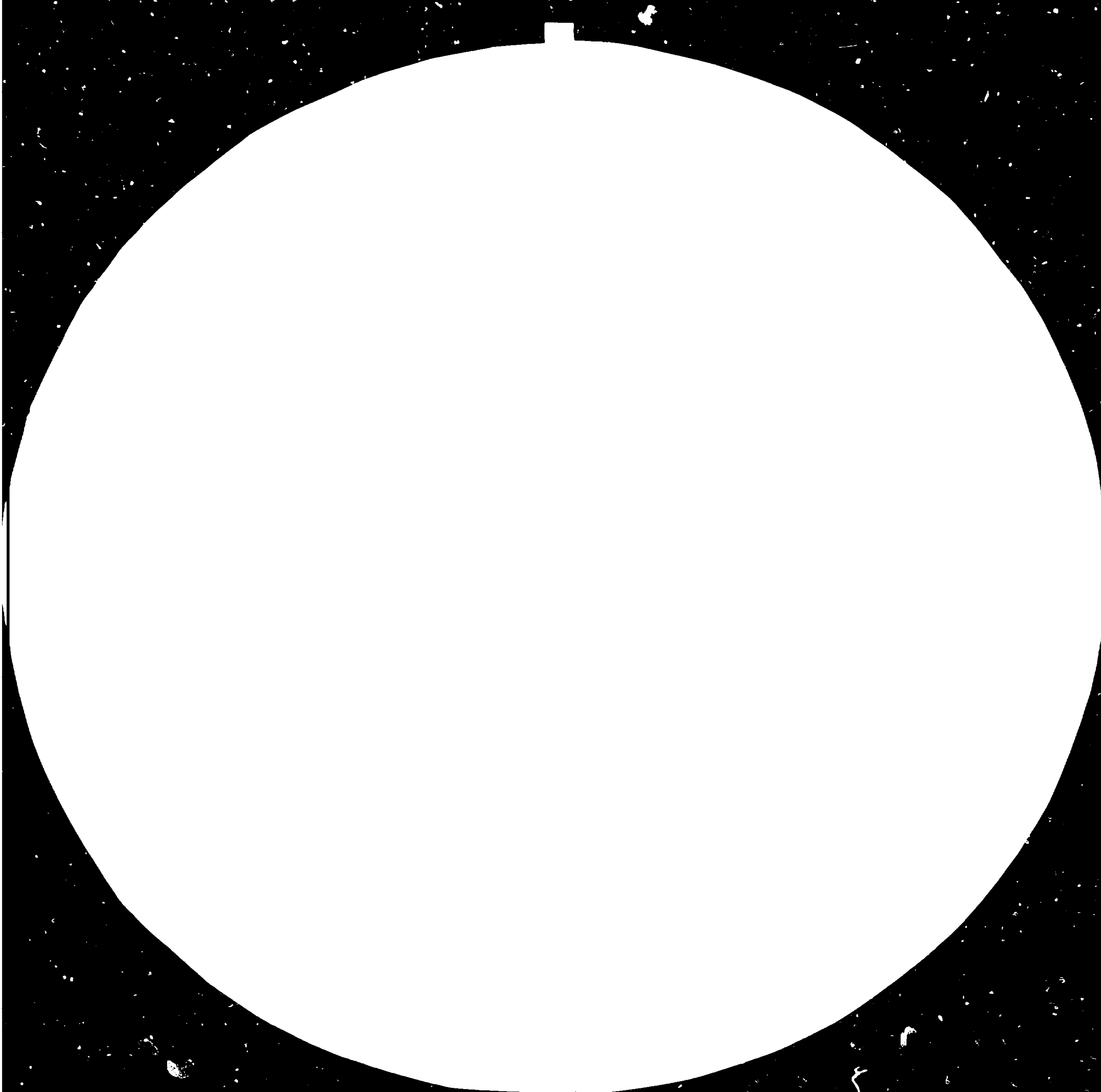

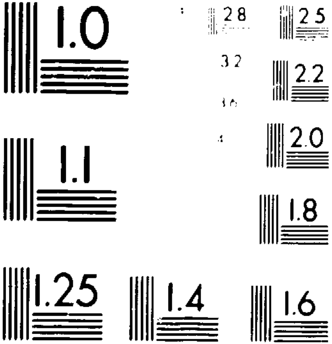
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

2. LIST OF MANUFACTURERS WITH EXPERIENCE OF THE SUPPLY OF SOME MACHINERY

NAME & ADDRESS OF COMPANY		COMMENTS
1.	ANHYDRO A/S OSTMARKEN 8 DK-2860 SOBORG-COPENHAGEN DENMARK	Flash driers for starch drying only.
2.	A P V MITCHELL 30 THORNTON ROAD THORNTON HEATH SURREY UK	Driers for starch and complete design engineering for glucose factories
3.	BERNAUER SECADORES INDUSTRIAIS LTDA CIAXA POSTAL 3748 SAO PAULO BRAZIL, S AMERICA	Manufacture and installation of driers. Flash fluid bed, rotary conveyor and bin dryers.
4.	BRITISH ARKADY CO LTD ARKADY SOYA MILLS OLD TRAFFORD MANCHESTER M16 ONJ UK	Mixers for dough making using cassava flour.
5.	BUELL LTD GEORGE STREET PARADE BIRMINGHAM B3 1QQ UK	Thermal drying of freshly harvested raw roots for pellet production.
6.	BUHLER-MAIG 19 STATION ROAD NEW BARNET HERTFORDSHIRE UK (Also HQ in Germany)	Pelletising of chips for feed and milling of dried chips
7.	NOVO INDUSTRI A/S NOVO ALLE DK 2880 BAGSVAERD DENMARK	Enzymes for hydrolysis of starch to modified products. Have process know-how especially ethanol and alcohol production.
8.	ROSIN ENGINEERING COMPANY 35/37 WILLIAM ROAD LONDON NW1 3ER UK	Drier manufacturers with experience of starch production from cassava.
9.	RONCAGLIA SpA MILLING ENGINEERING WORKS P O BOX 519 41100 MODENA ITALY	Flour milling and sifting machinery. Some experience of tapioca industry.
10.	WESTFALIA SEPARATOR AG D 4740 OELDE/WEST F WERNER-BABIC STR W GERMANY	Separators and decanters for starch separation.

BUDGET COSTINGS ERECTED IN ZAMBIA IN STERLING

A.	STARCH EXTRATION (see list)	579,000
B	GLUCOSE PRODUCTION	512,000
C.	DEXTRIN PRODUCTION	200,000
D.	UTILITIES (Part included in buildings)	268,000
E.	BUILDINGS & CIVILS & HOUSING	412,000
		1,971,000

REPORT 1 :
SCENARIO 1

CASSAVA FACTORY:THROUGHPUT

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1	QUANTITY:TONNES																
2	XXXXXXXXXXXXXXXXXX																
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
4D	YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5	ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	966.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
6D	YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	. 260
7	ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
8																	
9D	CHIP STARCH SOLD	T	35	35	207	252	297	342	387	432	477	522	567	612	612	612	612
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	CHIP SLURRY	T	364.6	364.6	2156	2625	3094	3562	4031	4500	4969	5437	5906	6375	6375	6375	6375
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
13	CHIPS INPUT CST	T	52.1	52.1	308.0	375.0	442.0	508.9	575.9	642.9	709.8	776.8	843.7	910.7	910.7	910.7	910.7
8																	
14D	GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
15D	YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
16	CHIP STARCH G	T	133.0	133.0	800.0	800.0	850.0	900.0	950.0	1000	1050	1100	1150	1200	1200	1200	1200
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
17	CHIP SLURRY G	T	1385	1385	8333	8333	8854	9375	9896	10417	10937	11458	11979	12500	12500	12500	12500
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
18	CHIPS INPUT G	T	197.9	197.9	1190	1190	1265	1339	1414	1488	1562	1637	1711	1786	1786	1786	1786
8																	
19D	DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
20D	YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
21	CHIP STARCH D	T	13.0	13.0	80.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0	120.0	120.0	120.0	120.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
22	CHIP SLURRY D	T	135.4	135.4	833.3	833.3	885.4	937.5	989.6	1042	1094	1146	1198	1250	1250	1250	1250
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
23	CHIPS INPUT D	T	19.3	19.3	119.0	119.0	126.5	133.9	141.4	148.8	156.2	163.7	171.1	178.6	178.6	178.6	178.6
8																	
24	TOTAL CHIPS INPUT	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																	
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
26	TOTAL STARCH SOLD	T	35.0	50.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
8																	
28	TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
8																	
29	TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
27	=================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 1: CASSAVA FACTORY THROUGHPUT

Report 1A

The model is primarily "driven" by the sales forecast. The quantity sales for each product may be seen in rows 3,9, 14, and 19.

Given the sales forecast this section of the model takes the sales forecast and calculates the tonnage of cassava roots and chips required to produce that quantity, using the conversion factors shown in each subsection. These conversion factors are based on the technical data described in technical section of the report.

It will be noted that over and above basic raw materials the model also calculates throughput of the two main stages of the factory ie slurry production and starch production. This is used in report three to assess the factory loading.

It will be noted that sales are apparently made during the construction period. This is done to generate costs for trial runs and chip purchases in season. By the simple device of valuing such sales at zero price, one months costs are automatically written off to developmental expenses in Period Yr.C 1. A further months chip stocks are raised as stock in the working capital routine. In period Yr.C 2 a further one month's sales are also raised to boost the cost loads on trial runs. The sales are however allowed to stand as revenue earning on the basis that having generated approximately three months' production resources they will produce one month's (ie 33⅓%) saleable product. Note that root starch production is only generated in period Yr C P2. since roots must bé procured fresh. (ie purchased and processed at the same time). Sales are valued at 50% to give a realistic saleable product outturn. This is expected to be higher than the chip starch outturn since root starch will be produced in the final trial month period.

REPORT 2 :
SCENARIO 1

CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	VALUE:INPUTS																
2	******************																
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
32	ROOTS CONSUMED		0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
8																	
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
34	CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
8																	
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
36	VALUE:OUTPUTS																
2	******************																
37D	RST PRICE	K/T	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
38	ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
8																	
39D	CST PRICE	K/T	0	800	800	800	800	800	800	800	800	800	800	800	800	900	800
9D	CHIP STARCH SOLD	T	35	35	207	252	297	342	387	432	477	522	567	612	612	612	612
40	CHIP STARCH		0	28	166	202	238	274	310	346	382	418	454	490	490	490	490
8																	
41D	GLUCOSE PRICE	K/T	0	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
14D	GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
42	CHIP GLUCOSE		0	146	860	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
8																	
43D	DEXTRIN PRICE	K/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
19D	DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
44	CHIP DEXTRIN		0	22	136	136	145	153	162	170	179	187	196	204	204	204	204
8																	
45	TOTAL SALES		0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 2: CASSAVA FACTORY: VALUE INPUTS/OUTPUTS

Report 2A

This report takes the physical quantities in report 1 and converts them to purchases and sales values using agreed prices. Note that the root starch price changes as explained in Appendix 1A and that glucose sales prices have been uplifted by the drum costs. Drum costs are to be recharged to customers and the model approach, showing a higher sale price on the one side, and a materials cost in the variable expenses, ensures that adequate stocks are generated in the working capital routines.

REPORT 3 :
SCENARIO 1

CASSAVA FACTORY : OPERATING TIMES

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
50 PROCESS:R TO RSL																
5 ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
51D PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
52 HOURS REQUIRED		0	12	75	75	75	75	75	75	75	75	75	75	75	75	75
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
55 WEEKS REQUIRED		0.0	0.2	1.1	1.1	1.1	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
57 PROCESS:RSL TO RST																
3D ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
58D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
59 HOURS REQUIRED		0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
60 WEEKS REQUIRED		0.0	0.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESS:C TO CSL																
28 TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
62D PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
63 HOURS REQUIRED		145	145	871	907	987	1067	1147	1228	1308	1388	1468	1548	1548	1548	1548
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
64 WEEKS REQUIRED		2.1	2.1	12.4	13.0	14.1	15.2	16.4	17.5	11.6	12.3	13.0	13.8	13.8	13.8	13.8
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESS:CSL TO CST																
29 TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
66D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
67 HOURS REQUIRED		181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
68 WEEKS REQUIRED		2.6	2.6	15.5	16.2	17.6	19.0	20.5	21.9	14.5	15.4	16.3	17.2	17.2	17.2	17.2
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
69 PROCESS:CST TO G																
14D GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
70D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
71 HOURS REQUIRED		133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
72 WEEKS REQUIRED		1.9	1.9	11.4	11.4	12.1	12.9	13.6	14.3	9.3	9.8	10.2	10.7	10.7	10.7	10.7
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
73 PROCESS:CST TO D																
19D DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
74D PROCESS RATE/HOUR		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
75 HOURS REQUIRED		81	81	500	500	531	563	594	625	656	688	719	750	750	750	750
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
76 WEEKS REQUIRED		1.2	1.2	7.1	7.1	7.6	8.0	8.5	8.9	5.8	6.1	6.4	6.7	6.7	6.7	6.7
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

REPORT: CASSAVA FACTORY: OPERATING TIMES

Report 3A

This routine is included to enable us to judge the factory load factors. The dextrin and glucose lines are separate to the main stream and have adequate capacity to process their offtake from the main line.

The critical process is slurry to starch by a small margin and to this must be added the element of the utilisation by the root starch production. Thus, maximum load is the sum of rows 60 and 68. This is reached in year 3 P2 after which the third shift is brought in.

Maximum capacity is conservatively set by assuming that the 1.25 tonne line has a practical operating optimum of 1 tonne per hour.

Shift hours are assumed to be as follows:

2 shift working = gross 16 hours

less changeover, start up and closedown = nett 14 hours.

3 shift working = gross 24 hours

less changeover etc = nett 22½ hours

(NB - the print out rounds up to 8 hours per shift but the model calculates on the actual of 7½ hours).

REPORT 4 : SCENARIO 1

CASSAVA FACTORY:OTHER VARIABLE COSTS

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
80	ELECTRICTY															
2	XXXXXXXXXXXXXXXXXX															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
81D	UNITS PER TONNE	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
82D	RATE PER UNIT	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
84	WATER															
2	XXXXXXXXXXXXXXXXXX															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
85D	LT.000 PER TONNE	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
86D	RATE PER 000LITRE	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
88	FUEL															
2	XXXXXXXXXXXXXXXXXX															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
89D	LITRES PER TONNE	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
90D	RATE PER LITRE	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
92	CHEMICALS															
2	XXXXXXXXXXXXXXXXXX															
14D	GLUCOSE SOLD T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
93D	EST.KGS PER TONNE	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
94D	COST PER KG.	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS	2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
100	PACKING MATERIALS															
2	XXXXXXXXXXXXXXXXXX															
26	TOTAL STARCH SOLD T	35.0	50.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
101D	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
102D	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST S	1	2	12	14	16	17	19	21	23	25	26	28	28	28	28
8																
14D	GLUCOSE SOLD T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
104D	DRUM UNIT WEIGHT KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
105D	DRUM UNIT COST	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST	20	20	120	120	128	135	143	150	158	165	173	180	180	180	180
8																
19D	DEXTRIN SOLD T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
107D	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
108D	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	TOTAL BAGS COST	1	1	3	3	3	4	4	4	4	4	5	5	5	5	5
8																
110	PACKING MATERIALS	22	22	135	137	147	156	166	175	185	194	204	213	213	213	213
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 4: CASSAVA FACTORY - OTHER VARIABLE COSTS

Report 4A

In expressing the variable costs and given that quantity figures, especially of electricity and water are so high the units per tonne and prices are equal to 000's units where appropriate.

Note that drum costs are generated by the programme. This is a contra in the profit and loss account with the inflated sales price. This ensures stock of drums are created for the working capital requirements.

REPORT 5 : CASSAVA FACTORY:FIXED ASSET MAINT/DEPR

SCENARIO 1

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
2	XXXXXXXXXXXXXXXXXX																
116D	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
117D	FACTORY BUILDINGS		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
118D	PLANT & EQUIPMENT		600	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
119D	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
120D	HOUSING		188	250	250	250	250	250	250	250	250	250	250	250	250	250	250
121	----------		------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
122	TOTAL COST		1258	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245
8																	
8																	
123D	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124D	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
125D	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
126D	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
127D	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
8																	
128	MAINTENANCE		7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
27	==========		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
8																	
8																	
129D	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130D	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131D	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
132D	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
133D	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
134	DEPRECIATION		0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
27	==========		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
8																	
135	TOTAL CUM DEP		0	0	127	254	381	508	635	762	889	1016	1143	1270	1397	1524	1651
121	----------		------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
8																	
141	NET FIXED ASSETS		1258	3245	3118	2991	2864	2737	2610	2483	2356	2229	2102	1975	1848	1721	1594
27	==========		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 5: CASSAVA FACTORY FIXED ASSET MAINT/DEPR

Report 5A

This routine assembles the maintenance and depreciation costs on fixed assets. Note that no depreciation costs are raised in the construction period and that only maintenance of vehicles is charged in this period.

After due thought it has been assumed that given a reasonable maintenance expenditure buildings should not be depreciated. In the case of plant and machinery it is assumed that the initial cost will include a supply of spares and that maintenance cost will rise progressively over the first five years levelling off at 20% per annum from year five onwards.

REPORT 6 :
SCENARIO 1

CASSAVA FACTORY:WORKING CAPITAL

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
145D	ROOT WEIGHT	T	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
146	ROOT VALUE		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8																	
147D	CHIP WEIGHT	T	269	45	1618	281	1833	330	2131	380	2429	430	2726	479	2875	479	2875
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
148	CHIP VALUE		54	9	324	56	367	66	426	76	486	86	545	96	575	96	575
8																	
110	PACKING MATERIALS		22	22	135	137	147	156	166	175	185	194	204	213	213	213	213
143D	STOCK PERIOD %		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
144	PACKING MATS VALUE		11	11	68	69	73	78	83	88	92	97	102	107	107	107	107
8																	
45	TOTAL SALES		0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
152D	STOCK WEEKS HLF YR		0	2	4	4	4	4	4	4	4	4	4	4	4	4	4
153	FINISHED GOODS VALUE		0	16	193	199	214	229	245	260	275	291	306	321	321	321	321
8																	
154	TOTAL STOCKS		65	36	585	324	654	374	754	424	854	474	953	524	1003	524	1003
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
155D	DEBTOR WEEKS HLF YR		0	4	6	6	6	6	6	6	6	6	6	6	6	6	6
156	DEBTORS/PREPAYMENTS		0	31	290	298	321	344	367	390	413	436	459	482	482	482	482
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
157D	CASH PERIOD HLF YR		0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
158	CASH		54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
160D	CREDITORS WEEKS HF Y		0	0	6	6	6	6	6	6	6	6	6	6	6	6	6
161	CREDITORS/ACCRUALS		0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
27	==================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 6: CASSAVA FACTORY: WORKING CAPITAL

Report 6A

The working capital requirements of agro-industrial units are frequently complicated by the need for seasonal buying of raw materials. The model is constructed to cope with the particular problems of the cassava market.

Period 1 July to December the majority of cassava has to be acquired. For period 2 January - June supplies will only be available in June when the buying season begins. The effect on working capital is one of high stocks and low cash holdings at end period 1 and the reverse at end period 2. As can be seen the model has been constructed to incorporate this important cash flow feature.

Other working capital requirements have been estimated on the following basis:

- packing materials at three months usage
- finished goods stocks at four weeks sales
- debtors at six weeks sales
- creditors at six weeks materials purchases

Debtors and finished goods stocks are the most significant items. These are relatively conservatively estimated since stocks are valued at full market value rather than at cost and debtors could be reduced by insisting on earlier payment. It is in fact not unknown, in developing countries, for producers of important industrial inputs to insist on payment in advance.

Since purchases are to be through NAMBOARD we assume that some credit will be available.

REPORT 7 :

SCENARIO 1

CASSAVA FACTORY:TAX/INT/DEBT/CAP

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
114D	CORPORATE TAX RATE %	0	0	0	0	0	0	0	0	0	0	0	0	45	45	45
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
111D	S-T DEBT INT RATE %	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12
112D	M-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
113D	L-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
162D	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
163D	CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
164D	MEDIUM-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
165D	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
166D	MEDIUM-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
167D	LONG-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
168D	LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
169D	LONG-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 7: CASSAVA FACTORY: TAX/INT/DEBT/CAP

Report 7A

This section of the model is the one through which the capitalisation, debt service and tax charges are entered and/or calculated into the main financial statements.

Interest charges have been assessed on the basis of rates currently been asked in Zambia. The term loan is set at 75% of plant and machinery which is the amount that the Development Bank of Zambia has indicated it would be prepared to lend. The loan is split into two to enable the model to accommodate two sorts of term loan financing should this be necessary in the future.

Debt service has been set at three years moratorium and three years repayment in six monthly rests. The Development Bank of Zambia has indicated to us the length of moratorium period they were willing to grant, whilst repayment has been set to enable the earliest practical repayment period.

It is assumed that the project will enjoy a tax holiday for the first five years' operations.

REPORT 8 : SCENARIO 1

CASSAVA FACTORY:PROFIT STATEMENTS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXXX															
171	SALES REVENUE:															
38	ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
40	CHIP STARCH	0	28	166	202	238	274	310	346	382	418	454	490	490	490	490
42	CHIP GLUCOSE	0	146	880	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
44	CHIP DEXTRIN	0	22	136	136	145	153	162	170	179	187	196	204	204	204	204
121																
45	TOTAL SALES	0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
172	RAW MATERIALS:															
32	ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
34	CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
121																
35	TOTAL DIR MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
121																
173	GROSS ADDED VALUE	(54)	143	895	918	988	1057	1127	1197	1267	1336	1406	1476	1476	1476	1476
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
95	CHEMICALS	2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
110	PACKING MATERIALS	22	22	135	137	147	156	166	175	185	194	204	213	213	213	213
121																
174	OTHER VARIABLE COSTS	40	42	252	257	277	296	315	334	353	372	391	410	410	410	410
121																
175	CONTRIBUTION	(94)	101	644	660	711	762	812	863	914	964	1015	1065	1065	1065	1065
176D	LABOUR & STAFF	73	72	117	117	117	117	117	117	152	152	152	152	152	152	152
177D	ELECTRICITY-FIXED	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
178D	WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
128	MAINTENANCE	7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
179D	MISCELLANEOUS	50	25	50	50	50	50	50	50	50	50	50	50	50	50	50
134	DEPRECIATION	0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
121																
180	TOTAL FIXED COSTS	133	107	442	442	472	472	502	502	567	567	597	597	597	597	597
121																
181	PROFIT BEFORE															
182	INTEREST & TAX	(227)	(6)	201	218	239	289	310	361	346	397	418	468	468	468	468
183	INTEREST:															
184	SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
185	MEDIUM-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
186	LONG-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
121																
187	TOTAL INTEREST	0	61	146	146	140	134	128	122	101	81	61	41	20	0	0
121																
188	PROFIT BEFORE TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	428	448	468	468
189	TAXATION	0	0	0	0	0	0	0	0	0	0	0	0	202	211	211
121																
190	PROFIT AFTER TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	428	246	258	258
27	==============	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 8: CASSAVA FACTORY: PROFIT STATEMENTS

Report 8A

The variable elements of the profit statement have been entered from the previously described reports where they are calculated. In terms of the fixed expenses the following have been estimated at fixed annual levels:

- electricity
- water
- miscellaneous.

Depreciation and annual maintenance are calculated as described in report 5.

The major item is staff and labour which has been estimated in accordance with the following table for operating periods:

	Basic Single Shift			Increment 2 Shifts		Increment 3 Shifts		
	No	Rate K	Total K	No	Total K	No	Total K	
Management	5	9,000	45,000	-		1	9,000	
Lab.Technician	1	3,960	3,960	-				
Foremen	2	5,280	10,560	1	5,280	1	5,280	
Mechanics	2	4,300	8,600	1	4,300	1	4,300	
Admin/Clerks	7	3,300	23,100	1	3,300	1	3,300	
Drivers	3	3,000	9,000	-		1	3,000	
Guards	4	2,410	9,640	1	2,410	1	2,410	
Operatives	12	2,665	31,980	12	31,980	12	31,980	
Labourers/ Groundsmen	20	1,645	32,900	4	6,580	4	6,580	
	56		174,740	20	53,850	22	65,850	
Add 7½ shift allowance					4,038		4,263	*
Total			174,740		57,888		70,113	

* NB Management does not receive shift allowance.

per period

2 shifts $= \dfrac{175{,}000 + 58{,}000}{2} = 116{,}500$

3 shifts $= \dfrac{175{,}000 + 58{,}000 + 70{,}000}{2} = 151{,}500$

In building up the construction period the cost levels for the majority of items are either generated within the model or set at levels commensurate with operating period costs. The major item not described by the schedules is again labour and staff which has been estimated as follows using the above annual salary rates:

- In the first six months staff will build up to the following levels.

	No		Rate K	Total K
Management	3	x	9000/2	13,500
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	2	x	3300/2	3,300
Drivers	1	x	3000/2	1,500
Guards	2	x	2410/2	2,410
Operatives	-		-	-
Labourers	4	x	1645/2	3,290
		Total		28,790

- In the second six months staff will build up to the following levels.

	No		Rate K	Total K
Management	4	x	9000/2	18,000
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	4	x	3300/2	6,600
Drivers	3	x	3000/2	4,500
Guards	3	x	2410/2	3,615
Operatives	-		-	-
Labourers	8	x	1645/2	6,580
		Total		44,085

Total labour and staff period Yr C P1	72,875	
say		73,000.

In the final six months of construction the full staffing will be engaged. However given the low output load this is expected only to be at a one shift level and in the case of operatives and factory labour, they will only be engaged during the last three months when trial runs take place. The staffing level is calculated as follows.

	No		Rate K	Total K
Management	5	x	9000/2	22,500
Foremen	2	x	5280/2	5,280
Lab.Technician	1	x	3960/2	1,980
Mechanics	2	x	4300/2	4,300
Clerical	7	x	3300/2	11,550
Guards	4	x	2410/2	4,820
Operatives	12	x	2665/4	7,995
Labourers/ Groundsmen	12	x	1645/2	9,870
Labourers/ Groundsmen	8	x	1645/4	3,290
				71,585
Say				72,000

REPORT 9 : SCENARIO 1

CASSAVA FACTORY:BALANCE SHEETS

Code	Item	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXXX															
141	NET FIXED ASSETS	1258	3245	3118	2991	2864	2737	2610	2483	2356	2229	2102	1975	1848	1721	1594
8																
191	CURRENT ASSETS:															
154	TOTAL STOCKS	65	36	585	324	654	374	754	424	854	474	953	524	1003	524	1003
156	DEBTORS/PREPAYMENTS	0	31	290	298	321	344	367	390	413	436	459	482	482	482	482
158	CASH	54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
121																
192	TOTAL CURRENT ASSETS	119	121	884	946	1032	1085	1187	1240	1343	1396	1498	1551	1581	1581	1581
8																
193	CURRENT LIABILITIES:															
161	CREDITORS/ACCRUALS	0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
162D	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
121																
194	TOTAL CURRENT															
195	LIABILITIES	0	0	483	386	293	200	107	114	121	128	134	141	141	141	141
121																
196	NET CURRENT ASSETS	119	121	400	559	739	885	1080	1126	1222	1268	1364	1410	1440	1440	1440
8																
197	SURPLUS CASH	47	140	44	85	132	269	382	403	379	476	564	773	816	1201	1586
8																
121																
198	TOTAL NET ASSETS	1423	3506	3562	3635	3734	3890	4073	4012	3957	3973	4030	4158	4104	4362	4617
27																
8																
199	FINANCED BY:															
200	CAPITAL	1650	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
201	RESERVES	(227)	(294)	(238)	(165)	(66)	90	273	512	757	1073	1430	1858	2104	2362	2619
121																
202	TOTAL EQUITY	1423	1706	1762	1835	1934	2090	2273	2512	2757	3073	3430	3858	4104	4362	4619
8																
166D	MEDIUM-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
169D	LONG-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
121																
205	CAPITAL EMPLOYED	1423	3506	3562	3635	3734	3890	4073	4012	3957	3973	4030	4158	4104	4362	4619
27																
8																

REPORT 9: CASSAVA FACTORY: BALANCE SHEETS

Report 9A

The model constructs the balance sheets largely from data already calculated in previous reports. One item however requires particular mention, namely cash surplus. This item is made necessary as a balancing item since the cash in hand figure is already fixed on the basis of the working capital requirement.

This form of presentation has the major advantage of demonstrating clearly the surplus cash flow build up and available for possible equity distributions. It must agree with the cumulative surplus cash flow shown in report 10, funds flow statement, and thus gives a clear audit check that the model logic is working. Finally in any one year this figure represents accumulated reserves not immediately required in the business and therefore enables us to refine capital employment, and thus the relevant ratios, to a figure representing the capital actually used in the business in the year in question.

REPORT 10 : SCENARIO 1

CASSAVA FACTORY:FUNDS FLOW STATEMENTS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	******************															
206	SOURCES OF FUNDS:															
190	PROFIT AFTER TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	426	246	258	258
134	DEPRECIATION	0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
207	M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	61	41	20	0	0
121																
208	CASH GENERATED FROM															
209	OPERATIONS	(227)	(6)	304	321	348	404	431	488	473	524	545	595	394	385	385
8																
1630	CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
1640	MEDIUM-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1670	LONG-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
121																
213	TOTAL SOURCES OF															
214	FUNDS	1423	2144	304	321	348	404	431	488	473	524	545	595	394	385	385
27																
8																
215	APPLICATIONS OF															
216	FUNDS:															
217	FIXED INVESTMENT	1258	1988	0	0	0	0	0	0	0	0	0	0	0	0	0
218	WORKING CAPITAL	119	2	279	159	179	146	196	46	96	46	96	46	30	0	0
8																
219	DEBT REPAYMENT:															
1650	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1680	LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
121																
222	TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	300	300	300	300	300	300	0	0
8																
183	INTEREST:															
185	MEDIUM-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
186	LONG-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
121																
207	M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	61	41	20	0	0
121																
223	TOTAL DEBT SERVICE	0	61	122	122	122	122	122	422	401	381	361	341	320	0	0
121																
224	TOTAL APPLICATIONS															
225	OF FUNDS	1377	2050	401	280	301	268	317	468	497	427	456	387	350	0	0
27																
226	SURPLUS CASH															
227	BALANCES:															
228	PERIOD	47	93	(96)	41	47	137	114	20	(24)	97	88	209	44	385	385
229	CUMULATIVE	47	140	44	85	132	269	382	403	379	476	564	773	816	1201	1586
27																

REPORT 10: CASSAVA FACTORY: FUNDS FLOW STATEMENT

Report 10A

This statement is computed by the model from the data in previous reports. It should be noted that term loan interest is included in both inflows and outflows to give a total debt service on which the debt service ratio can be computed.

REPORT 11 : SCENARIO 1

CASSAVA FACTORY:KEY FINANCIAL RATIOS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230 8	CONTRIBUTION MARGIN%	0	50	51	51	51	51	51	51	51	51	51	51	51	51	51
231 8	FIXED COST/SALES%	0	53	35	34	34	32	32	30	32	30	30	29	29	29	29
232 8	PROFIT AFT TAX/SALE%	0	(33)	4	6	7	10	11	14	14	17	18	20	12	12	12
233 8	PR AFT S-T INT/SALE%	0	(3)	14	15	16	19	19	21	19	21	21	22	22	22	22
234 8	PROFIT/CAP EMPLOYED%	(31.9)	(6.6)	4.8	10.2	11.1	12.8	14.3	16.6	17.9	18.7	20.2	21.3	22.8	21.5	20.3
235 8	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
236 8	CURRENT RATIO	0.0	0.0	1.8	2.4	3.5	5.4	11.1	10.9	11.1	10.9	11.1	11.0	11.2	11.2	11.2
237 8	DEBT/CAP EMPLOYED%	0	51	51	50	48	46	44	37	30	23	15	7	0	0	0
238 8	DEBT SERVICE COVER	0.0	(0.1)	2.5	2.6	2.9	3.3	3.5	1.2	1.2	1.4	1.5	1.7	1.2	0.0	0.0
239 8	PROFIT/NET CAP EMPLD	(32.9)	(6.9)	4.9	10.5	11.5	13.8	15.8	18.4	19.8	21.3	23.5	26.2	28.5	29.6	30.9
27																

REPORT 11: CASSAVA FACTORY: KEY FINANCIAL RATIOS

Report 11A

We have extracted certain key financial ratios to give an overview measurement of the project. The majority of the ratios are self explanatory and need no further comment as to their derivation. In the two profit/capital employed ratios we wish to clarify the basis of calculation as follows:

> These ratios have in the first instance been calculated as annual rates of return rather than six monthly rates. This has been done on the basis of adding the previous periods profit (loss) to that of the period being assessed, except in the first period where it has been necessary to multiply the current period profit or loss by two since no previous period exists.
>
> The difference between the profit/capital employed ratio (234) and the profit/net capital employed ratio (239) is that, in the latter case, the surplus cash figure in the balance sheet has been deducted from the capital employed to give the net figure.

REPORT 12 : SCENARIO 1

RATE OF RETURN ANALYSIS

		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
8 242	NET CASH FLOW	(3800)	187.6	426.9	677.1	855.6	998.2	748.4	769.1	769.1	2736
8 243U	DISCOUNT PERCENTAGE	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64
8 245	D. C. F.	(3800)	165.1	330.6	461.4	513.0	526.7	347.5	314.2	276.5	865.5
8 246	N. P. V.	0.5									

REPORT 12: RATE OF RETURN ANALYSIS

Report 12

The model calculates the NPV against a given rate of return. It will be noted that the cash flow expressed in six monthly periods in the main model has been consolidated to annual figures for this calculation and that whilst the print out shows only the first 15 periods, after which the annual results are the same, the model does hold a full 20 periods enabling ten years project life to be discounted.

In compiling the report we have established the IRR that yields an NPV as near as possible to zero by using a separate Finesse routine available as part of the package.

The final years cash flow has been adjusted to include the recovery of working capital together with the disposal of fixed assets as follows:

Land	100%
Buildings	50%
Plant	5%
Vehicles	10%
Working Capital	100%.

RESULTS OF SENSITIVITY RUNS

-15.00 PERCENT CHANGE IN SALES FACTOR

0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						

RESULTS IN PROFIT AFTER TAX

(212.64)	(82.10)	(40.67)	(26.37)	(7.33)	41.71	60.75	109.79	108.08	171.37	204.66	267.95	158.51
169.65	169.65	169.65	169.65	169.65	169.65	169.65						

-10.00 PERCENT CHANGE IN SALES FACTOR

0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						

RESULTS IN PROFIT AFTER TAX

(217.33)	(77.07)	(8.49)	6.65	28.22	79.79	101.34	152.93	153.76	219.58	255.40	321.22	187.81
198.95	198.95	198.95	198.95	198.95	198.95	198.95						

-5.00 PERCENT CHANGE IN SALES FACTOR

0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						

RESULTS IN PROFIT AFTER TAX

(222.02)	(72.03)	23.68	39.67	63.77	117.87	141.98	196.08	199.43	267.79	306.14	374.49	217.11
228.25	228.25	228.25	228.25	228.25	228.25	228.25						

0.00 PERCENT CHANGE IN SALES FACTOR

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						

RESULTS IN PROFIT AFTER TAX

(226.71)	(67.00)	55.86	72.69	99.32	155.96	182.59	239.23	245.11	316.00	356.88	427.77	246.41
257.55	257.55	257.55	257.55	257.55	257.55	257.55						

-15.00 PERCENT CHANGE IN SALES FACTOR

0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						

RESULTS IN CUMULATIVE

78.48	157.08	66.16	16.78	(30.96)	(1.41)	5.01	(97.36)	(243.61)	(284.40)	(334.07)	(278.28)	(318.07)
(21.42)	275.22	571.87	868.51	1165.16	1461.80	1758.45						

-10.00 PERCENT CHANGE IN SALES FACTOR

0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						

RESULTS IN CUMULATIVE

67.86	151.39	58.69	39.39	23.23	88.56	130.82	69.29	(36.07)	(30.95)	(34.66)	72.09	60.12
386.06	712.01	1037.96	1363.90	1689.85	2015.79	2341.74						

-5.00 PERCENT CHANGE IN SALES FACTOR

0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						

RESULTS IN CUMULATIVE

57.24	145.70	51.22	62.00	77.43	178.53	256.62	235.93	171.47	222.49	264.74	422.47	438.30
793.55	1148.80	1504.04	1859.29	2214.54	2569.78	2925.03						

0.00 PERCENT CHANGE IN SALES FACTOR

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						

RESULTS IN CUMULATIVE

46.62	140.01	43.75	84.61	131.62	268.51	382.42	402.58	379.01	475.94	564.15	772.84	816.49
1201.04	1585.58	1970.13	2354.68	2739.22	3123.77	3508.32						

RESULTS OF SENSITIVITY RUNS

-15.00 PERCENT CHANGE IN PRICE FACTOR												
0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						
RESULTS IN PROFIT AFTER TAX												
(226.71)	(97.36)	(132.54)	(121.11)	(109.40)	(67.69)	(55.98)	(14.27)	(23.31)	32.65	58.61	114.57	74.15
85.29	85.29	85.29	85.29	85.29	85.29	85.29						
-10.00 PERCENT CHANGE IN PRICE FACTOR												
0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						
RESULTS IN PROFIT AFTER TAX												
(226.71)	(87.24)	(69.74)	(56.51)	(39.83)	6.86	23.54	70.23	66.16	127.10	158.03	218.97	131.57
142.71	142.71	142.71	142.71	142.71	142.71	142.71						
-5.00 PERCENT CHANGE IN PRICE FACTOR												
0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						
RESULTS IN PROFIT AFTER TAX												
(226.71)	(77.12)	(6.94)	8.09	29.75	81.41	103.07	154.73	155.64	221.55	257.46	323.37	188.99
200.13	200.13	200.13	200.13	200.13	200.13	200.13						
0.00 PERCENT CHANGE IN PRICE FACTOR												
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						
RESULTS IN PROFIT AFTER TAX												
(226.71)	(67.00)	55.86	72.69	99.32	155.96	182.59	239.23	245.11	316.00	356.88	427.77	246.41
257.55	257.55	257.55	257.55	257.55	257.55	257.55						

-15.00 PERCENT CHANGE IN PRICE FACTOR												
0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						
RESULTS IN CUMULATIVE												
46.62	116.65	(102.55)	(253.42)	(409.38)	(490.41)	(609.33)	(836.93)	(1123.18)	(1303.86)	(1508.19)	(1606.96)	(1735.57)
(1523.28)	(1310.99)	(1098.71)	(886.42)	(674.13)	(461.85)	(249.56)						
-10.00 PERCENT CHANGE IN PRICE FACTOR												
0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						
RESULTS IN CUMULATIVE												
46.62	124.44	(53.78)	(140.74)	(229.05)	(237.44)	(278.74)	(423.76)	(622.45)	(710.60)	(817.41)	(813.69)	(884.88)
(615.18)	(345.47)	(75.76)	193.95	463.65	733.36	1003.07						
-5.00 PERCENT CHANGE IN PRICE FACTOR												
0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						
RESULTS IN CUMULATIVE												
4 .52	132.22	(5.02)	(28.07)	(48.71)	15.53	51.84	(10.59)	(121.72)	(117.33)	(126.63)	(20.42)	(34.20)
292.93	620.06	947.18	1274.31	1601.44	1928.57	2255.69						
0.00 PERCENT CHANGE IN PRICE FACTOR												
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						
RESULTS IN CUMULATIVE												
46.62	140.01	43.75	84.61	131.62	268.51	382.42	402.58	379.01	475.94	564.15	772.84	816.49
1201.04	1585.58	1970.13	2354.68	2739.22	3123.77	3508.32						

REPORT 1 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:THROUGHPUT

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1	QUANTITY:TONNES																
2	******************																
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
4D	YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5	ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
6D	YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
7	ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
8																	
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
13	CHIPS INPUT CST	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																	
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15D	YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
16	CHIP STARCH G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
17	CHIP SLURRY G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
18	CHIPS INPUT G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20D	YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
21	CHIP STARCH D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
22	CHIP SLURRY D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
23	CHIPS INPUT D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
24	TOTAL CHIPS INPUT	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																	
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
26	TOTAL STARCH SOLD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
28	TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
8																	
29	TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
27	===============		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 2 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	VALUE:INPUTS																
2	******************																
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
32	ROOTS CONSUMED		0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
8																	
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
34	CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
8																	
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
36	VALUE:OUTPUTS																
2	******************																
37D	RST PRICE	K/T	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
38	ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
8																	
39D	CST PRICE	K/T	0	800	800	800	800	800	800	800	800	800	800	800	800	800	800
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
40	CHIP STARCH		0	145	870	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
8																	
41D	GLUCOSE PRICE	K/T	0	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	CHIP GLUCOSE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
43D	DEXTRIN PRICE	K/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
45	TOTAL SALES		0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 3 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY : OPERATING TIMES

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
50 PROCESS:R TO RSL																
5 ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
51D PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
52 HOURS REQUIRED		0	12	75	75	75	75	75	75	75	75	75	75	75	75	75
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
55 WEEKS REQUIRED		0.0	0.2	1.1	1.1	1.1	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
57 PROCESS:RSL TO RST																
3D ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
58D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
59 HOURS REQUIRED		0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
60 WEEKS REQUIRED		0.0	0.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESS:C TO CSL																
28 TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
62D PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
63 HOURS REQUIRED		145	145	871	907	987	1067	1147	1228	1308	1388	1468	1548	1548	1548	1548
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
64 WEEKS REQUIRED		2.1	2.1	12.4	13.0	14.1	15.2	16.4	17.5	11.6	12.3	13.0	13.8	13.8	13.8	13.8
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESS:CSL TO CST																
29 TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
66D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
67 HOURS REQUIRED		181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
68 WEEKS REQUIRED		2.6	2.6	15.5	16.2	17.6	19.0	20.5	21.9	14.5	15.4	16.3	17.2	17.2	17.2	17.2
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
69 PROCESS:CST TO G																
14D GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70D PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
71 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
72 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
73 PROCESS:CST TO D																
19D DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74D PROCESS RATE/HOUR		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
75 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53D HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
76 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56D WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

REPORT 4 :
FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:OTHER VARIABLE COSTS

No.	Item	Unit	YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
80	ELECTRICTY																
2	******************																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
81D	UNITS PER TONNE		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
82D	RATE PER UNIT		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
83	ELECTRICITY-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
84	WATER																
2	******************																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
85D	LT.000 PER TONNE		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
86D	RATE PER 000LITRE		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
87	WATER-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
88	FUEL																
2	******************																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
89D	LITRES PER TONNE		132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
90D	RATE PER LITRE		0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL		12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
92	CHEMICALS																
2	******************																
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93D	EST.KGS PER TONNE		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
94D	COST PER KG.		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
100	PACKING MATERIALS																
2	******************																
26	TOTAL STARCH SOLD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
101D	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
102D	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST S		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
8																	
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104D	DRUM UNIT WEIGHT	KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
105D	DRUM UNIT COST		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107D	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
108D	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	TOTAL BAGS COST		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
110	PACKING MATERIALS		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT: 5 :   FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:FIXED ASSET MAINT/DEPR

			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
2	*******************																
116D	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
117D	FACTORY BUILDINGS		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
118D	PLANT & EQUIPMENT		600	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
119D	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
120D	HOUSING		188	250	250	250	250	250	250	250	250	250	250	250	250	250	250
122	TOTAL COST		1258	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345
123D	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124D	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
125D	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
126D	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
127D	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
128	MAINTENANCE		7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
129D	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130D	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131D	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
132D	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
133D	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134	DEPRECIATION		0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
135	TOTAL CUM DEP		0	0	82	164	246	328	410	492	574	656	738	820	902	984	1066
141	NET FIXED ASSETS		1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279

REPORT 6 : CASSAVA FACTORY:WORKING CAPITAL

FACTORY FOR CASSAVA STARCH ONLY

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
145D	ROOT WEIGHT	T	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
146	ROOT VALUE		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8																	
147D	CHIP WEIGHT	T	269	45	1618	281	1833	330	2131	380	2429	430	2726	479	2875	479	2875
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
148	CHIP VALUE		54	9	324	56	367	66	426	76	486	86	545	96	575	96	575
8																	
110	PACKING MATERIALS		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
143D	STOCK PERIOD %		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
144	PACKING MATS VALUE		4	4	24	25	27	29	31	33	35	37	39	41	41	41	41
8																	
45	TOTAL SALES		0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
152D	STOCK WEEKS HLF YR		0	2	4	4	4	4	4	4	4	4	4	4	4	4	4
153	FINISHED GOODS VALUE		0	12	143	151	163	175	188	200	212	225	237	249	249	249	249
8																	
154	TOTAL STOCKS		58	25	493	232	557	270	645	309	733	348	821	386	865	386	865
27	================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
155D	DEBTOR WEEKS HLF YR		0	4	6	6	6	6	6	6	6	6	6	6	6	6	6
156	DEBTORS/PREPAYMENTS		0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
27	================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
157D	CASH PERIOD HLF YR		0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
158	CASH		54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
27	================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
160D	CREDITORS WEEKS HF Y		0	0	6	6	6	6	6	6	6	6	6	6	6	6	6
161	CREDITORS/ACCRUALS		0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
27	================		=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 7 : CASSAVA FACTORY:TAX/INT/DEBT/CAP

FACTORY FOR CASSAVA STARCH ONLY

	YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
114D CORPORATE TAX RATE %	0	0	0	0	0	0	0	0	0	0	0	0	45	45	45
27															
111D S-T DEBT INT RATE %	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12
112D M-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
113D L-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
27															
162D SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
27															
163D CAPITAL	1600	100	0	0	0	0	0	0	0	0	0	0	0	0	0
27															
164D MEDIUM-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
165D MEDIUM-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
166D MEDIUM-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
27															
167D LONG-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
168D LONG-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
169D LONG-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
27															

REPORT 8 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:PROFIT STATEMENTS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXXX															
171	SALES REVENUE:															
38	ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
40	CHIP STARCH	0	145	870	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
42	CHIP GLUCOSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121																
45	TOTAL SALES	0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
172	RAW MATERIALS:															
32	ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
34	CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
121																
35	TOTAL DIR MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
121																
173	GROSS ADDED VALUE	(54)	91	583	606	656	706	757	807	857	907	958	1008	1008	1008	1008
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
95	CHEMICALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	PACKING MATERIALS	7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
121																
174	OTHER VARIABLE COSTS	23	25	152	157	170	183	196	209	222	235	247	260	260	260	260
121																
175	CONTRIBUTION	(77)	66	432	448	486	523	561	598	635	673	710	747	747	747	747
176D	LABOUR & STAFF	73	72	117	117	117	117	117	117	152	152	152	152	152	152	152
177D	ELECTRICITY-FIXED	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
178D	WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
128	MAINTENANCE	7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
179D	MISCELLANEOUS	50	25	50	50	50	50	50	50	50	50	50	50	50	50	50
134	DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
121																
180	TOTAL FIXED COSTS	133	107	352	352	371	371	390	390	443	443	462	462	462	462	462
121																
191	PROFIT BEFORE															
192	INTEREST & TAX	(210)	(41)	79	96	115	152	171	208	192	229	248	285	285	285	285
183	INTEREST:															
184	SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
185	MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
186	LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
121																
187	TOTAL INTEREST	0	41	105	105	99	93	87	81	68	54	41	27	14	0	0
121																
188	PROFIT BEFORE TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	272	285	285
189	TAXATION	0	0	0	0	0	0	0	0	0	0	0	0	122	128	128
121																
190	PROFIT AFTER TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 9 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:BALANCE SHEETS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXXX															
141	NET FIXED ASSETS	1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279
8																
191	CURRENT ASSETS:															
154	TOTAL STOCKS	58	25	493	232	557	270	645	309	733	348	321	386	865	386	865
156	DEBTORS/PREPAYMENTS	0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
158	CASH	54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
121																
192	TOTAL CURRENT ASSETS	112	102	720	782	858	900	992	1035	1127	1170	1262	1305	1335	1335	1335
8																
193	CURRENT LIABILITIES:															
161	CREDITORS/ACCRUALS	0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
162D	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
121																
194	TOTAL CURRENT															
195	LIABILITIES	0	0	483	386	293	200	107	114	121	128	134	141	141	141	141
121																
196	NET CURRENT ASSETS	112	102	236	395	564	700	886	921	1007	1043	1128	1164	1194	1194	1194
8																
197	SURPLUS CASH	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416
8																
121																
198	TOTAL NET ASSETS	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2888
27																
8																
199	FINANCED BY:															
200	CAPITAL	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
201	RESERVES	(210)	(292)	(317)	(326)	(310)	(251)	(167)	(40)	84	259	467	725	875	1031	1188
121																
202	TOTAL EQUITY	1390	1408	1383	1374	1390	1449	1533	1660	1784	1959	2167	2425	2575	2731	2888
8																
166D	MEDIUM-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
169D	LONG-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
121																
205	CAPITAL EMPLOYED	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2888
27																
8																

REPORT 10 : CASSAVA FACTORY:FUNDS FLOW STATEMENTS

FACTORY FOR CASSAVA STARCH ONLY

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	******************															
206	SOURCES OF FUNDS:															
190	PROFIT AFTER TAX	(210)	(52)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
134	DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
207	M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
208	CASH GENERATED FROM															
209	OPERATIONS	(210)	(41)	137	154	179	222	247	290	274	311	330	367	245	239	239
9																
163D	CAPITAL	1600	100	0	0	0	0	0	0	0	0	0	0	0	0	0
164D	MEDIUM-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
167D	LONG-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
213	TOTAL SOURCES OF															
214	FUNDS	1390	1259	137	154	179	222	247	290	274	311	330	367	245	239	239
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
8																
215	APPLICATIONS OF															
216	FUNDS:															
217	FIXED INVESTMENT	1258	1088	0	0	0	0	0	0	0	0	0	0	0	0	0
218	WORKING CAPITAL	112	(10)	134	159	169	136	185	36	85	36	85	36	30	(0)	0
3																
219	DEBT REPAYMENT:															
165D	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
168D	LONG-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
222	TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	200	200	200	200	200	200	0	0
8																
183	INTEREST:															
185	MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
186	LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
207	M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
223	TOTAL DEBT SERVICE	0	41	81	81	81	81	81	281	268	254	241	227	214	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
224	TOTAL APPLICATIONS															
225	OF FUNDS	1369	1118	215	240	250	217	266	317	353	290	326	263	243	(0)	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
226	SURPLUS CASH															
227	BALANCES:															
228	PERIOD	21	141	(78)	(86)	(71)	5	(20)	(27)	(79)	21	4	104	2	239	239
229	CUMULATIVE	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 11 : CASSAVA FACTORY:KEY FINANCIAL RATIOS

FACTORY FOR CASSAVA STARCH ONLY

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230	CONTRIBUTION MARGIN%	0	44	46	46	46	46	46	46	46	46	46	46	46	46	46
8 231	FIXED COST/SALES%	0	71	37	36	35	33	32	30	32	30	30	29	29	29	29
8 232	PROFIT AFT TAX/SALE%	0	(54)	(3)	(1)	1	5	7	10	9	12	13	16	9	10	10
8 233	PR AFT S-T INT/SALE%	0	(27)	6	7	9	12	14	16	14	16	16	18	18	18	18
8 234	PROFIT/CAP EMPLOYED%	(30.2)	(9.6)	0.5	5.0	6.5	8.9	11.2	14.0	15.5	16.5	18.6	20.3	22.2	20.9	19.8
8 235	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
8 236	CURRENT RATIO	0.0	0.0	1.5	2.0	2.9	4.5	9.3	9.1	9.3	9.2	9.4	9.2	9.4	9.4	9.4
8 237	DEBT/CAP EMPLOYED%	0	46	46	47	46	45	44	38	31	23	16	8	0	0	0
8 238	DEBT SERVICE COVER	0.0	(1.0)	1.7	1.9	2.2	2.7	3.0	1.0	1.0	1.2	1.4	1.6	1.1	0.0	0.0
8 239	PROFIT/NET CAP EMPLD	(30.7)	(10.3)	0.6	5.0	6.3	8.7	10.8	13.4	14.4	15.4	17.4	19.8	21.6	22.3	23.1
8 27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

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REPORT 12 : RATE OF RETURN ANALYSIS

FACTORY FOR CASSAVA STARCH ONLY

		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
8 242	NET CASH FLOW	(2900)	(1.6)	96.2	315.8	463.9	575.9	454.1	477.8	477.8	2153
8 243D	DISCOUNT PERCENTAGE	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
8 245	D. C. F.	(2900)	(1.5)	81.9	248.2	336.4	385.5	280.5	272.4	251.4	1045
8 246	N. P. V.	0.[illegible]									