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ID/WG.293/10
28 February 1979

ENGLISH

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Vienna, Austria, 26 - 30 March 1979

SIMPLIFIED AND ECONOMICAL CASSAVA STARCH PROCESS*

by

A. Caransa**

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id.79-1299

with 08701

United Nations Industrial Development Organization

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ABSTRACT
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ABSTRACT

SIMPLIFIED AND ECONOMICAL CASSAVA STARCH PROCESS*

by

A. Caransa **

Dorr-Oliver B.V., Amsterdam (Netherlands), in consultation with the Royal Tropical Institute in Amsterdam, have developed a simplified cassava starch flowsheet with the following features:

- very low water consumption, below 3 m3 per ton of tubers
- the heart of the system are hydrocyclones and DSM screens, with no moving parts, hence:
  - low maintenance cost
  - easy operation

  and other advantages are:
  - low space requirements
  - low installation cost
  - short detention time
  - high starch yield

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id.79-575

- the equipment is suitable for skid-mounting, which reduces installation cost to a minimum. This would even make it possible to move the plant to another harvesting site, when desired.

Basically the process is as follows:

After peeling, washing and disintegration of the tubers the fruitwater is removed in solid bowl centrifuges; by doing this the soluble carbo-hydrates together with the nitrogen containing compounds, which could cause fouling, are removed right at the start of the process. The fibers are removed on a small battery of Dorr-Oliver DSM screens; predewatering of the fibers takes place only when local circumstances require this. The crude, screened starch milk is degritted, concentrated and purified in a counter-current DorrClone washing system with a small amount of fresh water.

The entire system is suitable for cleaning in place and has been designed for continuous operation.

With the Dorr-Oliver system a high quality starch is produced which can serve as raw material for the production of glucose, dextrose, HFCS, alcohol, etc.

INTRODUCTION

Working as a food technologist or in a related function implies adhering to certain ethics. In my view one of the ethical consequences of our profession is the principle that whatever the soil produces should be treated with utmost care so that as little as possible is spoiled and optimal yields are guaranteed with the least environmental pollution. With this philosophy in mind, and, of course, with the aim to produce the best results for both user and supplier, Dorr-Oliver, in consultation with the Royal Tropical Institute in Amsterdam, have developed a simplified, compact cassava starch flowsheet. The main features of this new flowsheet are:

- very low water consumption, possibly, even the lowest in this industry;
- extraction and purification equipment with no moving parts, resulting in:
  - low maintenance cost;
  - no special skill required for the operators and further:
  - low space requirements, hence building will be inexpensive (low investment);
  - low installation cost;
  - short detention time, which means very hygienic operation;
  - high starch yield;
  - less than 3 m^3 of fresh water required per ton of tubers.

The equipment is designed for skid-mounting, which reduces installation cost to a minimum. In principle this makes it possible to move the plant to the harvesting site, when desired.

Basically the process is as follows:

After peeling, washing and desintegration of the tubers, the fruit-water is removed in solid bowl centrifuges; by doing this, the soluble carbohydrates together with the nitrogen containing compounds, sometimes referred to as latex, which could cause fouling, are removed right at the front end of the process. The fibers are removed on a small battery of Dorr-Oliver DSM screens. Predewatering and drying of the fibers takes place only when local circumstances make this economically feasible. The crude, screened starch milk is degritted, concentrated and purified in a counter-current Dorr Clone washing system with a small amount of washwater (3 kg of fresh water per kg of D.S. starch). This water forms part of the amount earlier mentioned. The entire system is suitable for cleaning in place and is designed for continuous around the clock operation.

The starch produced with this system can serve as raw material for the production of glucose, dextrose, HFCS, and the like.

For this distinguished audience there is no need to mention the parts of the world where cassava grows; the fact that it mainly appears between latitudes 30° north and south may imply certain constraints in terms of infrastructure, available skills, availability of utilities and the like.

It is with this in mind that we have decided to modernize and economize our flowsheet.

Before the designing of a plant is started, the product distribution of the raw material should be known.

Table I shows the chemical composition of cassava tubers as established by various researchers.

Table II shows a mass balance for a composition on which we have based our calculations.

TABLE I Chemical Composition of Whole Cassava Roots

(% dry basis)

Source	Fibre	Oil	Ash	Protein	Insol. Carb.	Sol. Carb.	Total carbohydr. excl. fibre
Grace	4	1	2	4	72	17	89
Regnaudin	8	2	-	4	77	9	86
Barrios & Bressani	5	1	3	2			89
Edwards	4	1	2	4	75	14	89
Corn Products					77		
Booth et al.					75	14	89
ASSUMED:	5	1	3	3	77	11	88

Source: Ir.F.W.Korthals Altes, R.T.I. Amsterdam.

TABLE II Mass Balance for Components and Products

(% dry basis)

Products	Total	Cellulose prod.	Cellulose tub.	Fat prod.	Fat tub.	Ash prod.	Ash tub.	Protein prod.	Protein tub.	Starch prod.	Starch tub.	Sol.carb. prod.	Sol.carb. tub.
In : Cassava tubers	100		5		1		3		3		77		11
Out: Peelings	5	40	2.0	2	0.1	6	0.3	6	0.3	46	2.3		
* Refuse	20	15	3.0	2	0.4	3	0.6	3	0.6	77	15.4		
Starch	58			0.3	0.2	0.2	0.1	0.2	0.1	99.3	57.6		
Fruit-water	17						2.0		2.0	2.0			11
TOTAL:	100		5.0		0.7		3.0		3.0		77.3		11

NOTE: The yield on extractable starch from granular starch in this case is $\frac{58}{68}$ = approx. 85%.

Source: Ir.F.W.Korthals Altes, R.T.I. Amsterdam.

From the above we arrive at a yield on extractable starch of approximately 85 %. This percentage is a somewhat conservative, but it allows us to find the optimum between investment and running cost on one side and expected yield on the other side.

The product distribution will then be as shown in table III.

TABLE III. Product Distribution after Peeling.

Per ton of tubers with a D.S. content of 35 %, the feed to the disintegrator (after peeling) contains:

	refuse:	0,20 x 350	=	70 kgs D.S.
	starch:	0,58 x 350	=	203 "
in fruitwater	starch:	0.02 x 350	=	7 "
	solubles:	0.15 x 350	=	52.5 "
D.S. TOTAL:				332.5 kgs D.S.

Table IV shows the block-flowsheet of the Dorr-Oliver cassava starch plant; only D.S. and fresh water are indicated.

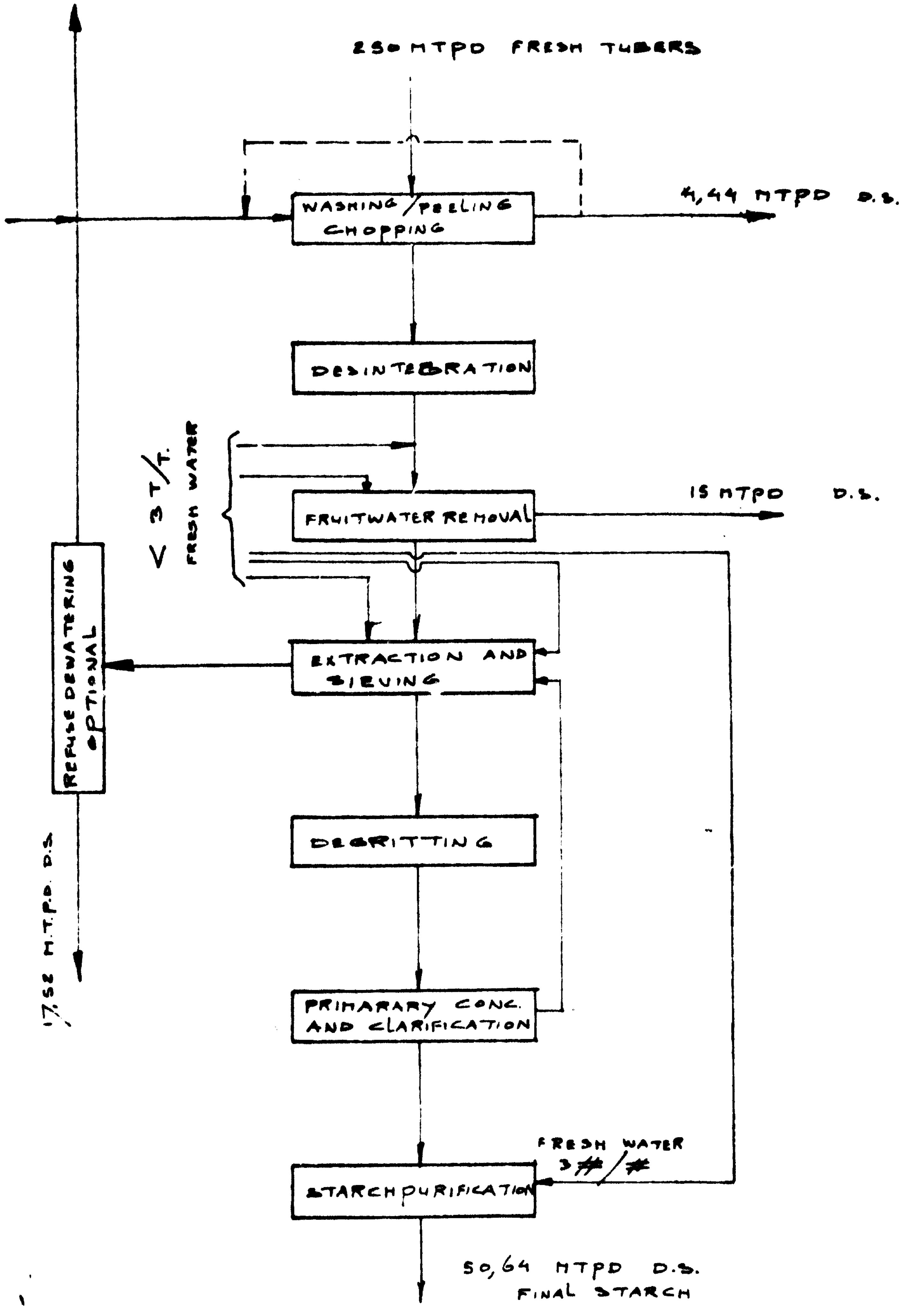
We have developed two standard flowsheets:

- one for plants having grinding capacities over 250 t/d of fresh tubers, and

- one for grinding capacities under 250 t/d.

For the larger plants we have based ourselves on the application

TABLE IV



250 MTPD FRESH TUBERS
WASHING/PEELING CHOPPING
4,44 MTPD D.S.
DESINTEGRATION
< 3 T/T. FRESH WATER
FRUITWATER REMOVAL
15 MTPD D.S.
EXTRACTION AND SIEVING
REFUSE DEWATERING OPTIONAL
17,52 M.T.P.D. D.S.
DEGRITTING
PRIMARARY CONC. AND CLARIFICATION
FRESH WATER 3#/#
STARCH PURIFICATION
50,64 MTPD D.S. FINAL STARCH

of Merco separators/concentrators for the primary separation and concentration, the smaller plants have an all-Dorr-Clone flowsheet.

Before showing the flowsheets, I should like to show you a table (table V), indicating the production of cassava roots plus the pertaining yield per ha. This table gives data obtained in 1976. In that year, the total world production was 105 million tons of cassava tubers.

For comparison, in 1950 this production was only 52 million tons, which means that this figure has more than doubled in 26 years.

From table V you will note an average yield of 10.45 t/ha. It should be borne in mind that with the present state of agricultural husbandry in the tropics, yields ranging from 30-50 t/ha and even higher ones can be obtained. I am mentioning these figures, since they (together with other socio-economical factors) can, or probably should, have a bearing on the design of the plant.

TABLE V. **Production and Yield of Cassava Roots of Main Countries in 1976.**

Country	Production (million tons)	Yield (tons/ha)
Brasil	27	12.7
Indonesia	12.5	8.3
Nigeria	11	10
Zaïre	10	8.9
Thailand	8	17.8
Tansania	5	5
		(average yield)
TOTAL:	73.5	10.45

Source: Ir.C.A. de Vries (R.T.I. Amsterdam)

DESCRIPTION OF THE PROCESS

In most of the countries where cassava is grown and processed, the availability of labour causes usually no problems of any significance. Nevertheless, it might prove to be of adventage in many countries to restrict the labour requirements. Anyway, hard physical labour in tropical conditions is unpleasant and this is only one reason why hand-harvesting should, and at present can be avoided. Various possibilities exist; from the hand-harvester developed by the University of Wageningen (Holland) via the Tropical Root Harvester developed in the U.K. to the highly sophisticated mechanical harvester for large quantities (500 tons of roots per day or more). For this machine a patent has been applied for and may have been granted in the meantime.

Although most suppliers of starch plants will not involve themselves in harvesting techniques, the subject is most certainly worth studying. Not only to be able to help the customer to select the proper tools, but also because of the effect the method of harvesting may have on the quality of the tubers to be processed.

This b ings us to the second p'ase of the proces'ing, namely, the reception and the selection of the roots. Unfortunately, there is still no substitute for the hand-picking of foreign matter on a selecting belt.

For small size plants, grinding 100-250 tons of tubers per day, this is no major problem, but for bigger size plants ergonomical problems may play an important role here.

Directly related with this is the desintegration of the roots. Although the available literature generally indicates rasps for this purpose, and to our knowledge rasps are widely propagated and used, the application of Hammermills deserves careful consideration. Not because of higher yields, but because of less downtime and/or lower investment cost. Also because of the fact that its robustness makes a Hammermill less sensitive for impurities like wood and stones which may still be present in the flow of tubers entering the plant.

With the increasing number of (semi) mechanical harvesters, this problem gains importance.

DETAILS OF OPERATION

Although I may assume that the root reception and handling needs no further explanation, a few words should be devoted to the subject of peeling. That the outer peel has to be removed needs no further elaboration. It is different though with regard to the inner layer, the so-called sub-periderm. This inner layer, usually approx. 2-3 mm thick, contains only 50 % in weight of the starch as compared to the core of the tuber. Further, it contains most of the hydrocyanic acid (HCN), which may cause some discolouring of the starch. Although tests have shown that the discolouring migrates through the starch and can be washed out, it is a matter of economy whether or not to remove the sub-periderm. Part of it comes off during peeling anyway.

After peeling and washing, chopping (if required) and disintegration take place. Economy dictates the use of one or two disintegration stages; it is common practice to install only one stage.

The crude water used for washing the tubers is only polluted with solids such as sand, clay and the like. Therefore, it can be re-used to a large extent after having been treated in a settling tank or a simple solids removing process. This applies only if none or very little fruitwater is re-cycled.

To prevent plugging of the subsequent equipment the disintegrated product, diluted with some fresh water, is fed into a decanter to remove the soluble carbohydrates (sugars, etc.) together with the nitrogen containing compounds. This material is sometimes referred to as "latex".

In order to carry out the fruitwater removal under optimal conditions no SO_2 is added at this stage (ahead of the decanter). This is done to prevent a change of the viscosity of the starch and to prevent coagulation.

Part of the fruitwater coming from the decanter can be used for washing the tubers, also because this water generally does not contain more than 3 kg of starch per ton of tubers.

For the evacuation of the concentrated product from the decanter some fresh water should be used; this water can be made up with the required amount of SO_2. The ultimate application of the final starch is decisive for the amount of SO_2; usually, the final starch does not contain, or rather is not supposed to contain more than 25-30 ppm SO_2 on D.S. starch.

The extraction and screening take place on three or four stages of Dorr-Oliver DSM screens. Whether three or four stages of (300 degr.) screens will be installed, is again a matter of economics. It is an evaluation of a slightly higher starch yield versus higher investment, and running cost. The DSM screens allow for cleaning in place as well as during operation. The special construction of the feed spout prevents plugging of these all stainless steel units.

Dorr-Oliver DSM screens are unique in that a counter-current system is able to combine two steps: extraction and sieving. Basically no fresh water is used for counter-current washing, because the overflow of the clarification system is used here.

The average slotwidth applied for the screen surfaces is 75 micron; the overflow of the final screening stage has a D.S. content of approx. 35-40 g/l. It depends on local circumstances whether this refuse is used as undewatered animal feed slurry, fertilizer or whether it is (pre) dewatered and/or dried. Dewatering can be effected on pressband filters or in plate and frame presses. After screening the crude starch milk is degritted in 3" nylon Dorr Clones. The degritted starch milk is further treated in an all-Dorr Clone system.

Concentration, clarification, starch recovery and starch purification are all effected in Dorr-Oliver Multicyclones. The absence of moving parts, except from the pumps reduces the maintenance cost considerably. This is both in terms of labour and replacement parts. Also the down-time is reduced to a minimum.

Further in this system the ultimate application of the starch dictates whether 5 or 6 refining stages have to be installed. Since cassava is low in protein anyhow, 5 stages will usually be sufficient to arrive at a starch quality which is suitable as raw material for more than 100 derivatives.

Since the starch is lower in amylose content than most other starches, it is excellent for food products, but also for sizing of high quality paper. Further applications are glucose, dextrine and invert sugar; the lower protein content of the product reduces the utility consumption. Ethyl alcohol, butanol and acetone are already known and accepted fermentation products, but cassava starch is also a cheap raw material for the production of single cell protein and amylase.

Depending on the further use of the starch, same is either pumped to the refinery for conversion or dewatered on a Dorr-Oliver rotary vacuum 'heelcake' filter with scraper discharge and dried in a plashdryer. Both of our standard plants allow for future extension.

GENERAL REMARKS

It is impossible to give a general calculation on the feasibility of a cassava starch plant, since virtually all factors such as land and site prepar tion, infrastructure, c st of raw materia cost of water and fuel, labour cost and many other factors will vary from country to country.

Two factors remain relatively constant, namely:

a) The cost of the plant itself. The difference in the price for a completely installed plant handling 600 t/d and one handling 100 t/d is only a factor 2. This means that a 600 t/d plant costs only double as much as a 100 t/d plant.

b) As shown earlier the grinding capacity has very little bearing on the size of the building, and anyway, unless special precautions against earthquakes have to be taken, the building can be one without closed walls, and of light, low cost construction material.

Publications of the Tropical Products Institute in London (1974) show that a plant producing approx. 10,000 tons of commercial starch per year, that means handling approx. 55,000 t/y of tubers (250-275 t/d) can produce an R.O.I. of 12 %. The power consumption for such a plant, based on 100 % dry starch, amounts to approx. 300 kW. This is compiled as follows:

- root handling and disintegration	approx.	130 kW
- fruitwater removal, extraction and starch purification	"	130 kW
- starch drying (100 %)	"	40 kW
TOTAL	approx.	300 kW

Consumption Figures

Based on the system used for root washing and peeling with currently standard equipment in this industry: 2000 m^3 crude water of which at least 75 % can be reused. Of fresh softened water (less than 10 degr. German hardness with less than 0.3 mg Fe/l) approx. 700 m^3/day is needed. Additional consumption figures are shown in Table VI.

TABLE VI. Consumption Figures of a 250-300 t/d Plant.

power consumption	approx.	300 kW
crude water consumption	"	2000 m^3/d
softened water consumption	"	700-750 m^3/d
building	"	2600 m^3
labour requirements	per shift:	5 unskilled
		6 skilled
		1 fitter
		1 electrician
	daytime only:	general manager
		wetmill superintendant
		chemist(s)
		clark(s)

SUMMARY

A simplified and economical cassava starch process is discussed, allowing low capital, installation and running cost.

The plant is designed for skid mounting and is suitable for cleaning in place. Further, the plant is designed for 200-250 days per year operation during 24 hours per day.

Indications regarding product distribution, personnel, utility, space and power consumption are given.

Information received in various forms from the Royal Tropical Institute in Amsterdam and from the Tropical Products Institute in London is gratefully acknowledged.

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