Harvesting and Processing

PROCEEDINGS OF A WORKSHOP HELD AT
CITRAL, CALID, COLOMBIA
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Cassava Harvesting and Processing

Proceedings of a workshop held at CIAT, Cali, Colombia, 24–28 April 1978

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Large-Scale Cassava Starch Extraction Processes

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Abstract. Today, efficient systems exist for large-scale cassava starch production. Based on technology and equipment developed in various starch industries, they make full use of raw materials and produce a minimum of wastewater. Their main problem, which is largely beyond their control, is the supply of raw materials, which rarely exceeds 50 t/hour.

Starch production today is mainly based on four different raw materials — corn, wheat, potato, and cassava. All of the corresponding processes have their own characteristics and problems, although the potato and cassava processes are similar. In one way, however, the cassava process is unique: it is applied in very small rural production units as well as large industrial plants, although the technology is quite different in the two.

Big plants in the cassava starch industry are themselves small compared with cornstarch plants, for which a production of 4 t/hour is considered small. In contrast, a cassava starch production of 2 t/hour is already rather big. In the following, I will refer to large-scale cassava plants as those that grind roots at 6 t/hour or more. At this capacity and above, all the factories use basically the same technology, but small changes can be made to introduce more efficient running procedures and use of the raw materials. Large cassava starch plants must deal effectively with three major problems: ensuring a constant supply of roots; utilizing the by-products; and controlling wastewater.

The most important problem is ensuring the supply of roots. Because the roots should be processed within 24–48 hours of harvesting, transportation from the field is a major consideration and must be well organized. The factory must work in close cooperation with the farmers or have its own estate, so that planning for growing, transportation, and production can be centralized. At best, the supply of roots to the factory will in most cases not exceed 50 t/hour.

The second problem is to devise a satisfactory use for the by-products, which account for about 30% of the dry substance and are wasted by most starch producers. The starch is only about 25% of the roots; 65% is water, and the remaining 10% other components.

The third major problem is factory effluents, which become a headache sooner or later, independent of location. It is, therefore, advisable to design the process with wastewater control in mind. This involves mainly recycling and reusing process water in the system, thereby reducing effluent volumes as well as freshwater requirements.

Process Description

The process can best be explained by examining the block diagram in Fig. 1. The fresh roots arrive at the factory in most instances by trucks and should be received in an organized manner. The capacity of the receiving department should be two to three times the average capacity of the factory because roots normally are not delivered more than 8–12 hours every day.

Weighing and sampling of the roots are the basis for paying the supplier and can be done in many ways. The roots may need to be dry cleaned before they are weighed because of large amounts of soil and small rocks. The cleanings should, if possible, be sent back to the fields directly, and the roots should be placed in storage in sufficient quantities to cover that part of the day when deliveries are not made. With a proper design of storage, feeding into the plant is no problem.

The roots are then washed and peeled in two steps. The washing is separated from the peeling to utilize the water more efficiently. The water in
Fig. 1. Cassava starch processing.

the washing section picks up soil and dirt and must be continually clarified. At clarification, a sediment, coarse particles, and an effluent carrying solubles and very fine particles are obtained. The effluent is the only wastewater stream from the system and should be taken to a biological treatment plant for reduction of the BOD (biological oxygen demand). When washed, the roots are peeled, i.e., the outer layer of cork is removed. The peelings are screened off and coarsely ground. The peeled roots are chopped and funneled through a metering device, such as a hopper with a screw conveyor. The level of roots in the hopper, or funnel, indicates when too many or too few roots are being fed into the system. A simple device can be set up to signal the operator at the root storage to increase or decrease the flow.

The next step is disintegration, which frees the starch particles from the fibre. The starch is then extracted, or washed out and separated from the fibre. At disintegration, it is important to separate the starch without creating too many fine fibres, which make extraction more difficult and less efficient. Although complete extraction is the ideal, it may not be economical because of the power it consumes.

After starch extraction, the pulp is a by-product that can be mixed with the ground peelings and allowed to ferment in a tank to be later dewatered and dried for use as a cattle feed. The chemical reaction in fermentation reduces the toxicity and makes dewatering possible.

The extracted starch is concentrated and refined in a separation section, whereafter the soluble components are removed through washing, and the refined product is mechanically dewatered and dried.

Although the process is not completely bottled up, it does not let much material go to waste. If the effluent produced at biological waste treatment plants and the soil are discounted, the dry substance recovery is about 94% (Fig. 2).

As always in wet processing, a good dry substance recovery is intimately linked to a low freshwater consumption. In the process presented here, less than 1 m$^3$ of fresh water is used per ton of roots (Fig. 3).

Fresh water is used only in washing so that the starch can be given a very thorough cleaning to remove all solubles. The water is then circulated into the separation section, where all the fibres, protein, and most other impurities are removed. From there, it can be used in the extraction, disintegration, peeling, and washing sections. The water that goes to extraction will be purified in the separation process and recirculated, ensuring enough washwater for efficient extraction without large amounts of fresh water. Only small amounts of water are needed in disintegration, and the water used in peeling flows to the washing section and can be regulated to move rapidly enough to be reasonably clean. From the washing section, it flows to the wastewater treatment plant.

### Plant Description

A plant implementing the process concepts discussed above can, of course, be designed in more than one way. The following description is based on well-proven equipment and practical experience. It should also compare favourably with alternatives regarding investments (Fig. 4).

When the trucks arrive at the plant, they first pass a weigh bridge. Afterwards, they dump their loads onto a conveyor belt that delivers the roots to a reel for dry cleaning before storing. The soil collected during cleaning is weighed for each
truckload and is subtracted from the original weight. The difference is the weight of the cassava roots, which in the meantime have been moved onto conveyer belts to be deposited in big storage bins. The bins open at the bottom and drop the roots onto another conveyer belt that brings them to the washer. Through this system, labour is kept to a minimum, and the first-in-first-out concept can be strictly applied. The washer is a trough in which the roots are cleaned but not peeled. The water in the washer is continuously recycled over a screen and a hydrocyclone, which take out the solids. As new water is added to the washer, the excess is drawn off and sent to biological treatment. The roots are lifted over a dividing wall to the peeler that agitates them—roughly enough to remove the outer layer. The water in the peeler is sent through a screen, leaving the peelings, which are ground coarsely and sent to the fermentation vessel. The cleaned and peeled roots then go to a chopper, which breaks them up into pieces of 30–50 mm. The chopped material is collected in a hopper with a screw conveyer that feeds the disintegrators. Although in the past disintegration took two steps, it is now accomplished in a single trip through sawblade rasps.

After disintegration, the starch is extracted from the fibres in a six-stage system. The first five stages are static screens and the last stage is a rotating conical screen. The pulp goes to the fermentation vessel, and is finally dewatered with a belt press — equipment that has proven itself for this application. The dewatered material is mixed with recycled dry material and moves to a dryer.

![Fig. 2. Starch and by-products produced from 1000 kg of roots.](image)

![Fig. 3. Wastewater control measures for starch production.](image)
The starch milk from the first screening enters a tank that feeds a centrifugal nozzle separator. It should be noted that this tank is the only one in the process. In contrast, most large factories use a series of tanks through which the starch milk travels. The more tanks there are, the greater the risk of biological degradation of the starch. Operating without tanks has been made possible by pumps that are specifically designed for starch processes. Even without tanks, or rather because of the absence of tanks, the system is very easy to control and operate. A unique automatic control on the centrifugal separator regulates the amount of starch drawn from the tanks, and the level of starch milk within the tank is a measure of the inflow, i.e., whether the feed from disintegration is in step with refining. If not, the screw conveyer to the rasps can be adjusted. The final cleaning of the starch is done by hydrocyclones in four to eight stages, and then the starch is collected and fed through a peeler centrifuge for dewatering before drying. Vacuum filters may be used instead of the centrifuge but are not economical for big plants.

Fig. 4. Large-scale cassava starch plant.