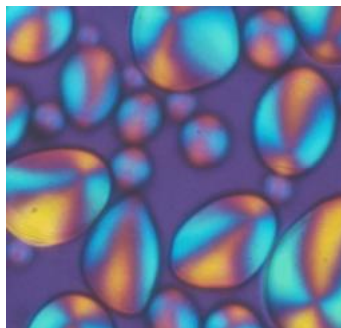




International
Starch
Institute

SWEET POTATO STARCH PRODUCTION

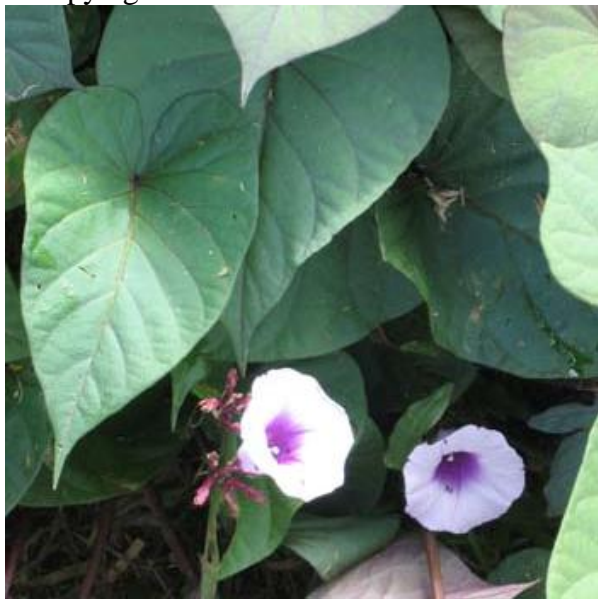
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Starch Technology

THE OCCURRENCE OF STARCH

Starch makes up the nutritive reserves of many plants. During the growing season, the green leaves collect solar energy. This energy is transported as a sugar solution down to the tubers, and it is down there the sugar is converted to starch in the form of tiny granules occupying most of the cell interior.



The conversion of sugar to starch takes place by means of enzymes. Enzymes are also responsible for the re-conversion of starch to sugar, when energy is needed for sprouting and growth.

SWEET POTATOES.

The sweet potato, *Ipomoea batatas*, belongs to the family *Convolvulaceae*. It is a tuberous-rooted perennial, usually grown as an annual. It originated in the Yucatan peninsula in Latin America, is now grown extensively in a wide range of environments between latitude 40°N and 40°S and from sea level up to an altitude of 2-300 metres. It is adaptable and can grow under many different ecological conditions. It has a shorter growth period than most other tuber crops (three to five months) and under suitable climatic conditions it shows no marked seasonality.

Sweet potatoes are high in dry matter (typically 30%) and a good source of energy, carotene, niacin, thiamine, riboflavin, and certain minerals. Lipids contribute to the palatability of the tubers. A typical composition of the tuber is:

| Content | Amount |
|--------------|-----------------|
| Protein | 0.95 - 2.4 % |
| Fat | 0.12 - 1.0 % |
| Carbohydrate | 25 - 32 % |
| Fibre | 0.9 - 1.6 % |
| Calcium | 290 - 340 ppm |
| Phosphorus | 490 - 510 ppm |
| Iron | 1 - 10 ppm |
| Sodium | 130 - 520 ppm |
| Potassium | 2000 - 3730 ppm |
| Magnesium | 240 - 260 ppm |

Source: Ministry of Agriculture, Malaysia

Starch constitutes the major part of the carbohydrate - the rest made up of mono- and disaccharides in particular maltose and saccharose. Typical starch content is 22%. The starch granules vary in size from 4-40 μm with 19 μm in average. The amylose content is approximately 18%.

QUALITY OF RAW MATERIAL.

The tubers are living plants and need air for respiration and life activity. During storage the tubers consume a small amount of their own starch to maintain life functions. This requires fresh air and the respiration causes development of heat. If the tubers get warm, respiration increases raising the temperature





further. A lot of starch is used for respiration and the tubers will die of heat.

Unfavourable storage and transport conditions cause starch losses and, in the worst case, dead and smashed raw materials, which are disruptive for the process. Therefore tubers are processed in the order they are delivered to the factory, and the tubers must be processed within 24 hours after harvest.

TUBER RECEPTION.

At the factory gate the lorry is weighed on a platform scale. Tubers are sampled and washed. The ratio of dirt is found as the difference in weight before and after washing and the starch content is calculated from the density determined by the under-water weight method. Both figures are used to settle the account with the farmers and encourage the delivery of high quality tubers rich in starch.

The tubers are stored in the reception yard on a concrete floor in a way to accomplish the processing of the oldest tubers first. At this point the tubers are still bulky with an average weight of 600 - 650 kg per m³. A yard conveyor below floor level enables the use of a Bobcat for feeding the factory.

RAW MATERIAL HANDLING.

Loose soil is removed by a rotating bar screen prior to washing. Thorough dirt removal lessens the problems with stones and sand later. The soil also contains considerable quantities of nutrients, which will dissolve in the washing water and contribute to the environmental burden created by the effluent.

From the bar screen the tubers enter the washing station via a stone catcher. Rotary washers introduced by International Starch Institute have proved their efficiency.

EFFICIENT WASHING HELPS REFINING.

Many impurities resemble starch in specific weight and size, so washing is the only way to get rid of them. The rubbing in the washing machine is a most important quality factor.

The quantity of impurities adhering to the surface upon delivery depends to a great extent on weather conditions and the soil.

The wash water may be recycled after filtering on a rotary screen and settling of sand in basins. Spent process water (fruit water) from the refining station replaces the loss of wash water.



Washing Line.

RASPING.



Raspers

The washed roots are conveyed to a buffer bin feeding the rasps. Rasping (grating) is the first step in the starch extraction process. The goal is to open the tuber cells and release

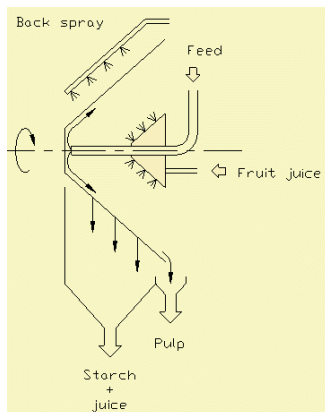
starch granules. The slurry (rasping) obtained can be considered as a mixture of pulp (cell walls), fruit juice and starch. On modern high-speed machines, rasping is a one-pass operation only. An even feed of rasping is essential for a steady flow throughout the rest of the plant.

USE OF SULPHITE.

The cell juice is rich in sugar and protein. When opening the cells, the juice is instantly exposed to air and reacts with the oxygen, forming coloured components adhering to the starch.

Food grade sulphur dioxide gas or sodium bisulphite solution has to be added. The great reduction potential of the sulphite prevents discoloration. Sufficient sulphite has to be added to turn the juice and pulp light yellow.

EXTRACTION.



Powerful flushing is needed to release the starch granules from the cells - the cells are torn apart in the rasper and form a filtering mat retaining the starch. Water has previously been

used for the extraction, but today the extraction takes place in closed systems,

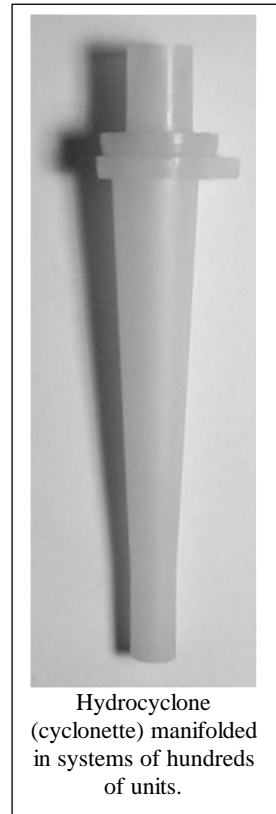


allowing the use of the juice itself or process water from the refining step.

The starch is flushed out and leaves the extraction sieves along with the fruit juice. The cell walls (pulp) can be concentrated further on dewatering sieves to a drip-dry pulp with 12 - 15 % dry matter. The pulp is cell residues rich in fibres digestible by ruminants.

The extraction takes place on rotating conical sieves. The high efficiency makes it feasible to utilise high quality sieve plates made of stainless steel, which will withstand abrasion and CIP-chemicals. The sieve plates have long perforations that are only 125 microns across.

The extraction is a counter current process. It is followed by a fine fibre washing - also on conical sieves. The washed fibres are combined with the pulp and may be used as cattle feed.



THE MILLENNIUM PROCESS.

Excess juice is removed on a hydrocyclone concentrator. The concentrated starch - crude starch milk - is washed on the refining line.

The concentrating and refining lines split the crude starch milk in:

- Starch *Underflow*
- Fruit Juice *Overflow 1. split*
- Fruit Water *Overflow 2. split*



Fruit juice is the natural juice initially removed in the concentrators. Fruit water is spend process water mixed up with residual fruit juice removed during refining. The split of the effluent in fruit juice and fruit water is an option of the Millennium process.

REFINING

The concentrated crude starch milk is washed with fresh process water in order to remove residual fruit juice and impurities.

With hydrocyclones it is feasible to reduce fibre and juice to low levels with a minimum of fresh water. To save rinsing water the wash is done counter currently - i.e. the incoming fresh water is used on the very last step and the overflow is reused for dilution on the previous step, and so on.

In the strong gravitational fields of a hydrocyclone and a centrifuge, the starch settles quickly, while fibres (pulp residuals) just float in the water.



Hydrocyclone Line

The hydrocyclone has no moving parts and the separation is dependent on the pressure difference over the cyclone.

Each hydrocyclone is adjusted to force the light fraction of fibres and the smaller starch granules into the overflow and the larger



starch granules into the underflow.

Impurities of equal density with starch cannot be separated from starch by centrifugal force. That is why it is so important to remove as many impurities as possible from the tuber surface in the washing station.

Although some impurities go with the starch in the underflow, there is, by means of a sieve, a last chance to remove the larger particles. Impurities not removed this way are not removable by any known technique.

No significant amount of juice is left in the starch. The colour or whiteness may be improved by the use of sulphite in the right place and dosage, and by removing iron and manganese from the process water. Oxides of iron and manganese (e.g. rust) are dark coloured components, which have to be removed in the water treatment plant.

CIP - CLEANING IN PLACE.

Cleaning in Place is done with caustic and hypochlorite as cleaning agents. Caustic is a powerful agent for removal of the protein build-up on the interior walls and the hypochlorite is an efficient germ killer.

During CIP it is of the utmost importance to keep the pipes filled up. Tanks are most efficiently CIP^{ed} with rotating disc nozzles - and covered tanks are required.

DRYING AND SIFTING.



The purified starch milk is dewatered on a continuous rotating vacuum filter or a batch operated peeler centrifuge.

The moist dewatered starch is dried in a flash dryer with hot air. The inlet air temperature is moderate. High temperatures may increase cold-water soluble starch. The moisture of sweet potato starch after drying is normally 12-13%.



Separation of starch and drying air.

In stead of drying right away the purified starch milk may be modified by chemical means before drying or it may be hydrolyzed and further processed into glucose or fructose syrup.



MODIFICATION

Most starch is used for industrial purposes. Starch may be modified to meet the requirements of the end-user giving rise to a range of specialty products. Sophisticated techniques are applied.

By applying different reaction conditions - temperature, pH, additives - and strict process control, specialty products with unique properties are made.



These specialty products are called modified starches. They retain their original granule form and thereby resemble the native (unmodified) starch in appearance, but the modification has introduced improved qualities in the starch when cooked. The paste may have obtained improved clarity, viscosity, film-forming ability, etc.

By chemical wet modification it is possible to make thin-boiling starches enabling high concentrations of starch in sizes for paper and textile as well as a range of starch ethers and esters.

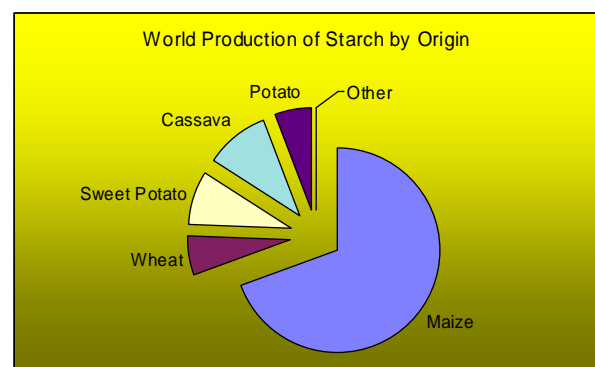
APPLICATION.

Sweet potato starch is used in the manufacture of sweeteners, sizing of paper and textile and it is an excellent food starch used as a thickener and stabilizer. The pulp is used as cattle feed. Juice and spent process water are valuable fertilizers disposed of by land spreading or fermentation of bio-gas.

Sweet potato starch is particular valued as a food starch and may replace mung bean starch in the popular glass noodles. Modified sweet potato starch is even better for the purpose. Being a pure renewable natural polymer starch has a multitude of applications.

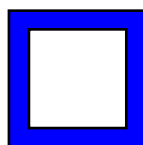


Starch finds uses in fast food, sweets, sausages, tablets, paper, corrugated board, textiles etc. and plays a prominent part in our everyday life.



Sweet potato starch represents 9% of the World production of starch estimated to a total of 60 million t in 2004. Practically all is produced in East Asia with more than 97% in China.

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