International
Starch
Institute

BANANA STARCH PRODUCTION

TM28-2e

THE OCCURRENCE OF STARCH

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

Banana, common name for any of a genus of tropical, tree-like herbaceous plants and also for their fruit. Species of the genus are native to South East Asia but are now grown extensively in all tropical countries for their fruit, fiber, or foliage. The banana is a large, herbaceous perennial with a plant rhizome (underground stem), from which the plant is perpetuated by sprouts or suckers. In the tropics the stems are annual—that is, they die after the fruit ripens, and new stems are developed from buds on the rhizome. These buds are the common means of propagating and making new plantations, and the growth is so rapid that the fruit is usually ripe within ten months after the offsets are planted. When fully grown the stem reaches a height of 3 to 12 m (10 to 40 ft) and is surmounted by a crown of large oar-shaped leaves up to 3 m (10 ft) long, with a strong fleshy stalk and midrib. The flowers are borne in great spikes from the center of the crown of leaves and are arranged in whorls along the spike; the female flowers occupy the base of the spike, and the males the apex. The fruits vary in length from about 10 to 30 cm (4 to 12 in). The average weight of a bunch is about 11 kg (25 lb), but individual bunches often exceed 18 kg (40 lb). A stem bears only once, dies down, and is replaced by sprouts, two or three of which are allowed to bear fruit.

The fruit of the plantain, or cooking banana, is larger, coarser, and less sweet than the kinds that are generally eaten raw. The edible part of a banana contains, on average, 75 per cent water, 21 per cent carbohydrate, and about 1 per cent each of fat, protein, fiber, and ash. Other parts of the plant abound in fiber, which can be used in the manufacture of paper and cordage. One species is the source of Manila hemp (abaca). The cooking banana may serve as a raw material for starch manufacture. The starch content is about 25%. The granule size is in the range 5 - 70 microns - a little smaller than potato starch - but it resembles corn starch in paste characteristics like gelati-

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nizing temperature and gel strength, but with higher peak viscosity.

Half of the world's banana crops are grown in Africa, and much of the produce is used locally. The leading banana-export regions are Central America and northern South America.

Scientific classification: Bananas make up the genus *Musa* of the family *Musaceae*. The plantain, or cooking banana, is classified as *Musa* x *paradisiaca.* The Manila hemp or abaca is classified as *Musa textilis.*

QUALITY OF RAW MATERIAL.

Unfavourable storage conditions cause starch losses and, in the worst case, dead and smashed raw materials, which are disruptive for the process. Therefore raw material is processed in the order they are delivered to the factory, and the fruit must be processed immediately of harvest.

Supplies of bad raw materials have to be rejected.

Raspers

RASPING.

Rasping is the first step in the starch extraction process. The goal is to open the fruit cells and release the starch granules. The slurry obtained can be considered as a mixture of pulp (cell walls), fruit juice, and starch. With modern high-speed raspers, rasping is a one-pass operation only. An even feed of the raspers is essential for a steady flow throughout the rest of the plant.

USE OF SULPHUR.

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, which may adhere to the starch.

Food grade sulphur dioxide gas or sodium-bisulphite-solution therefore has to be added. The great reduction potential of the sulphur compounds prevents discoloration. Sufficient sulphur 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 trying to retain 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 that is flushed out leaves the extraction sieves along with the fruit juice. The cell walls (pulp) can be concentrated further on pulp dewatering sieves. In this case the pulp leaves the dewatering sieves wet, but drip-dry with 10 - 15 % dry matter.

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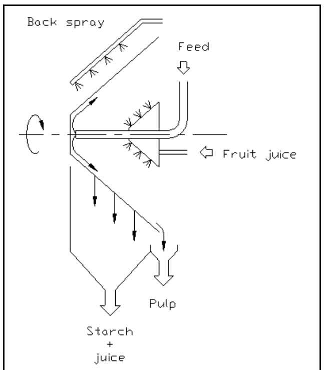
The extraction takes place on rotating conical sieves. The high efficiency makes it feasible to utilise high quality sieve plates made of stainless steel, which will withstand abrasion and CIP-chemicals. The sieve plates have long perforations that are only 125 microns across.

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

FRUIT JUICE.

Much of the nutritional values of the fruit are retained in the juice. During a feeding trial International Starch Institute demonstrated the nutritional value of undiluted and untreated fruit juice from potato as an ingredient in swine wet feed. The success depends on logistics.



Operating Principle of a Starch Extractor.

International Starch Institute in co-operation with the Danish environmental authorities carried out a three-year trial for optimising the recycling of fruit juice and found it was an attractive substitute for artificial fertilizer. Understandably farmspreading is the preferred methods of utilizing the nutrients of the juice, wherever land is available.

CONCENTRATING THE CRUDE STARCH SLURRY.

As much juice as possible is excreted on a couple of hydrocyclone batteries. The starch leaves the concentrator as a pumpable concentrated slurry.

REFINING

It now remains to purify the crude starch slurry (suspension) and remove residual fruit juice and impurities. The way it is done is more or less based on the same principles used when removing soapy water from the laundry - you wring and soak in clean water repeatedly. Everyone doing laundry realises how often it is necessary to wring before the rinsing water is all clear, and that the harder you wring the fewer rinsing steps are required.


Starch Extractor.

In the same way the starch slurry is diluted and concentrated again and again. 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.


Screening Units.

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Refining is based on the differences in weight density between water, fibres, and starch:

	Density g/ml
Starch	1.55
Cell walls (fibres)	1.05
Water	1.00
Soil, sand	above 2

In the strong gravitational fields of a hydro-cyclone, the starch settles quickly, while fibres (pulp residuals) just float in the water. The juice is directly diluted in the water and goes with the water phase.

By creating a water flow moving towards the starch, lots of fibres that are floating in the water may be forced into the overflow. Soil, sand, and many fungi, etc. are of equal density, or heavier than starch and it is not possible to separate these particles from starch by centrifugal force.

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.

HYDROCYCLONES.

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

For the removal of the juice hydrocyclones are far more efficient than centrifuges due to the large dilution rate of the feasible application of multi-stage units.

Starch is among the most pure of all agricultural products. Actually, purity is the most important parameter for being competitive.

No significant amount of juice is left in the starch. The colour or whiteness may be improved by the use of sulphur 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.

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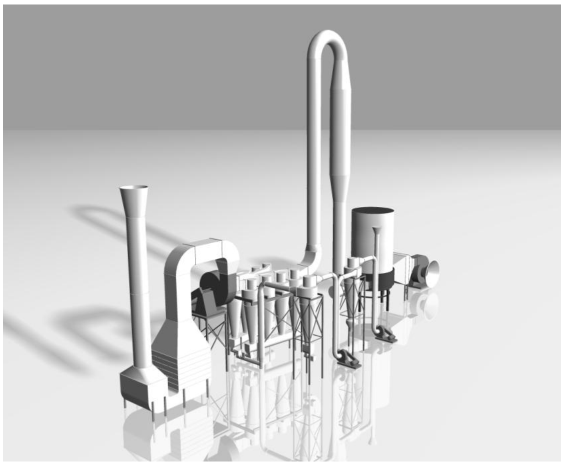

Dryer

DRYING AND SIFTING.

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

Dewatering

The moist dewatered starch is dried in a flash dryer with hot air. The inlet air temperature is moderate. The moisture of banana starch after drying is 12-13%.

The starch is sifted on a fine sieve in order to remove any scale formed in screw conveyors etc. A coarse screen with larger openings may protect the fine sieve.

Reactors

MODIFICATION

Most starch is used for industrial purposes. Starches are tailor made to meet the requirements of the end-user giving rise to a range of specialty products. Many and sophisticated techniques are applied. A most versatile principle comprises a three step wet modification:

Preparation
⇓
Reaction
⇓
Finishing

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 still 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.

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APPLICATION.

Most of the world's starch supplies are derived from grains (corn, sorghum, wheat, rice), the major tuber crops (potato, sweet potato, cassava, arrowroot) or the pith of the sago palm. While starches from these various plant sources vary slightly in their physical and chemical properties, they can be substituted for each other across a wide spectrum of end uses. Banana starch - a newcomer on the international starch market - may equally well substitute the more traditional starches for a range of application within the paper and textile industry and as a texturizer and binder in foods. Banana starch is an equally valued carbohydrate source for the biochemical industry, for alcohol, sweeteners and as a worth adjunct.

Being a pure renewable natural polymer starch has a multitude of applications.

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

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