VOGELBUSCH
Biocommodities

Starch Sweetener

Process Technology

VOGELBUSCH STARCH SWEETENER PLANTS
Know-how and technology licensing

Sugars derived from starch are a group of derivatives that are used extensively as natural sweeteners in foodstuff and beverages or as components in other fields such as pharmaceuticals and cosmetics. In the bioprocess industry, they serve as a substrate to manufacture fermentation products.

With its extensive know-how from other proprietary bioprocesses, Vogelbusch designs and supplies sweetener production lines for a range of low and high-DE products, with expertise covering all process steps from starch hydrolysis using dedicated enzymes to the downstream operations required for product isolation and concentration.

HOW YOU BENEFIT FROM OUR EXPERTISE

We are ready to assist with:

- A thorough understanding of the processes involved
- Options from simple to complex product ranges
- Knowledge regarding the integration of third-party technologies
- Complementing technologies (alcohol, organic acids)

OUR SERVICES FOR STARCH SWEETENER PLANTS

Vogelbusch provides engineering, consultancy and contracting services, and licenses technology. Our service packages for installing starch sweetener facilities include:

- Process know-how and basic engineering for the process plant
- Detail engineering or a review of client's detail engineering
- Supplying equipment and/or providing procurement assistance
- Supplying automation including field instruments, and hardware and software for control systems
- Supervising plant installation and commissioning

Alternatively, complete process lines may be provided as an EPC solution.

Our highly qualified experts are also available to upgrade or expand existing facilities.

DESIGN OPTION

Product mix

Given the wide range of starch sweeteners that can be made from starch milk, the choice and possibly flexibility of the product range is of great importance. A suitable product mix is put together on the basis of market demand, the necessities of the bioprocess, and last but not least the investment and operating costs. Depending on the complexity of the project, the optimal combination and necessary minimum capacities can be determined in a conceptual study.

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GRAIN PROCESSING PLANTS AND BIOREFINERIES

Grain processing includes the production of a whole range of valuable products and by-products such as

- Starch milk
- Dry native starch
- Modified starch and other upgraded starch products
- Dry protein fraction (gluten)
- Germ fraction
- Dried and pelletized animal fodder
- Alcohol from low quality starch

Processing of biobased chemicals

Starch or its hydrolysates can serve as carbohydrate source for the fermentation of biochemicals such as

- Amino acids
- Organic acids
- Antibiotics
- Polysaccharides
- Vitamins
- Enzymes
- Bioplastics

Our services for grain processing plants

We realize biochemical production plants based on our proprietary bioprocess technology and with licensed technology from third parties.

We can assist you throughout the entire grain-processing project, from the selection of raw materials through to the final product range. Contact us for:

- Pre-engineering and feasibility studies including comparison of different plant configurations and product scenarios
- Comparison of technical and commercial solutions of third-party suppliers (dry milling, wet milling, starch processing, product drying, ...)
- Cross-system integration of technologies from individual package suppliers during the development and execution phase of the project
- General mass and energy balances to identify secondary energy sources for cross-sectional energy recuperation and other synergies

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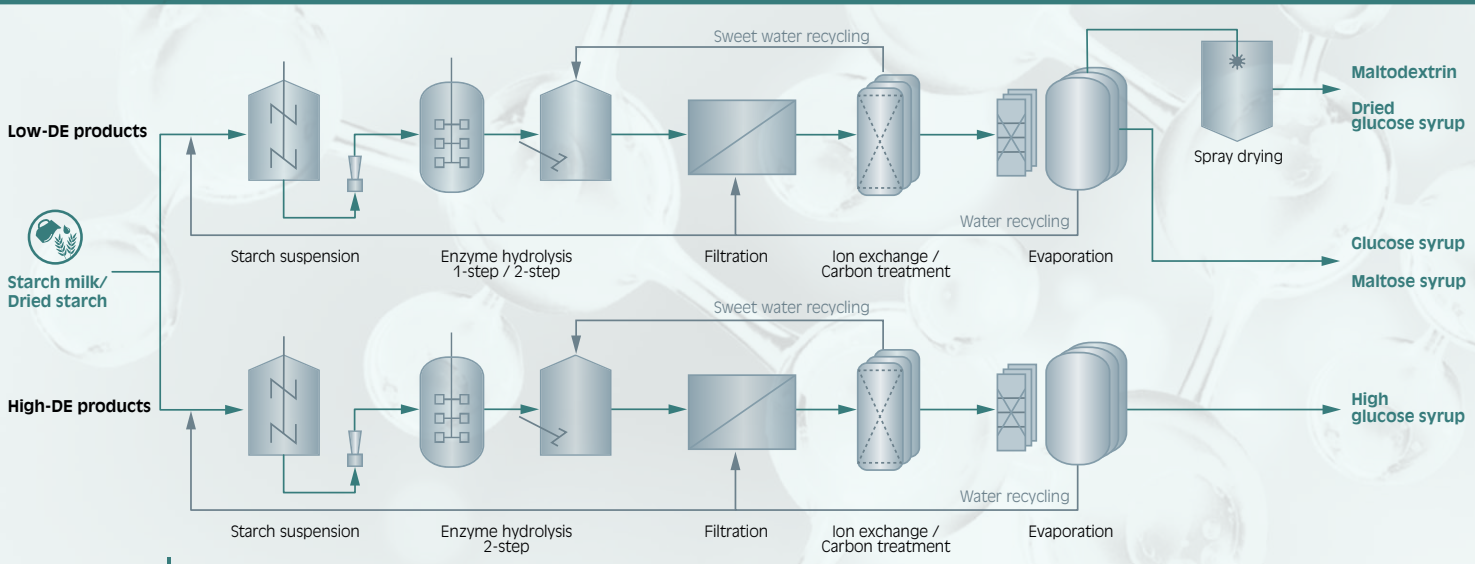

Starch is a carbohydrate extracted in the form of starch milk from agricultural raw materials such as corn, wheat, rice, and cassava. Our sweetener technologies are based on the processing of starch milk, the isolation process for which is offered by specialized companies.

We design process plants that use enzymes to convert starch milk into different types of starch sugars. We select the conversion conditions depending on the desired sugar profile and functionality, followed by a series of carefully adjusted purification processes along with the finishing for liquid and crystalline varieties.

When it comes to the general installation of grain processing facilities, we can carry out customized cross-integration for other technologies involved (dry milling, wet milling, by-product processing) with the sweetener production or for other upgraded starch or fermentation products.

PRODUCT CATEGORIES

Starch molecules are large polysaccharides that consist of individual sugar components. Certain bioprocessing steps can cleave them to form monosaccharides (glucose) and higher sugars (such as maltose, isomaltose, maltotriose).

The various types of sweeteners derived from starch differ considerably in their content of glucose and higher sugars and in their dextrose equivalent (DE). The DE indicates the respective degree of conversion of starch to glucose.

DEXTROSE EQUIVALENT	DESIGNATION	MAIN COMPONENT	CUSTOMARY FINISHING
< DE20	Maltodextrin	higher sugars (virtually no monomers)	spray dried powder
DE20-65	Low-DE glucose	higher sugars	liquid or dried powder (< DE40)
DE30-55	Maltose syrups	maltose	liquid
> DE96	High-DE glucose	glucose	liquid or crystalline

Syrups with a DE of between 20 and 98 are generally referred to as glucose syrups.

HIGH GLUCOSE SYRUP

CONVERSION

The feedstock for glucose production is starch milk with a purity ranging from 98 to 99% of starch in dry substance. Starch suspended in water is buffered in a vessel to allow homogenization of the starch slurry. The starch is broken down by means of a hydrolysis reaction using a two-step enzymatic process.

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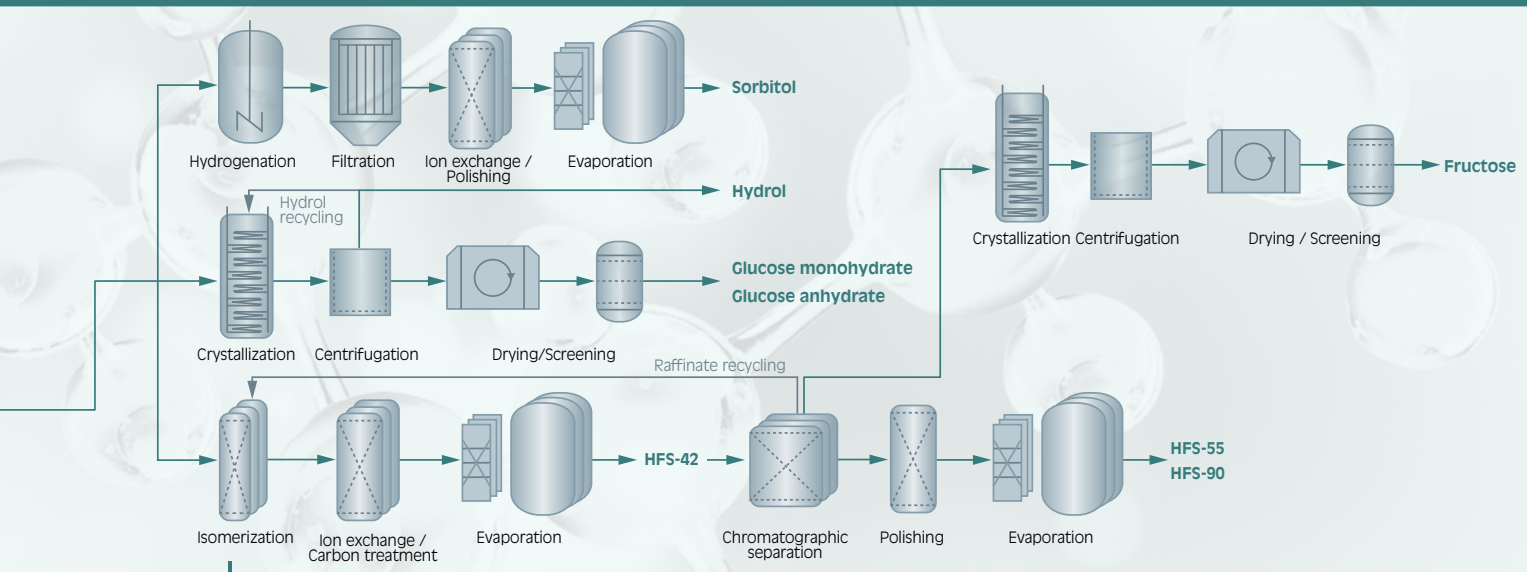


In the **liquefaction** step, the starch slurry is treated with specific enzymes and fed into a jet cooker, where the starch is pre-liquefied. This solution is cooled down in an expansion vessel and placed in a holding tank for final liquefaction.

In the **saccharification** tanks, further types of enzymes are added to convert the liquefied substrate into glucose. By carefully selecting the process parameters, DE values of up to 98 can be reached within 30 to 60 hours of saccharification time.

PURIFICATION

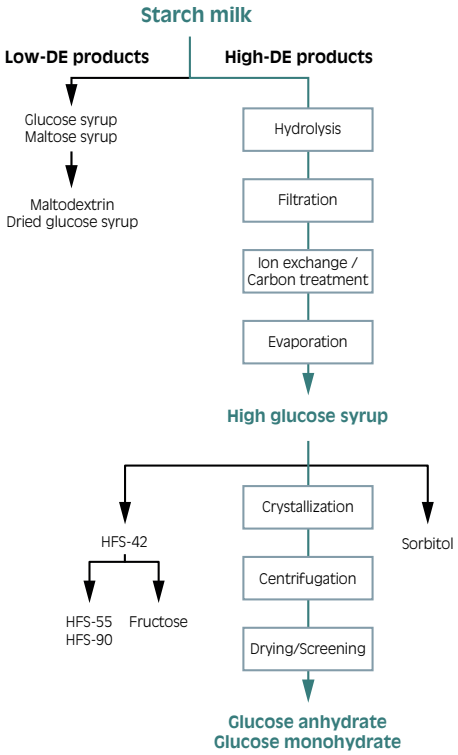
A broad range of filtration technologies is available to separate suspended particles such as fibers and proteins. State-of-the-art cross-flow membranes are employed to recover the separated solids for use as a valuable animal fodder. Filter presses, vacuum drum or disk filters continue to be a cheap alternative and hence are widely used mainly for processing low-DE syrups.

The filtered solution is deashed in pairs of strong acidic and weak basic ion exchangers. Color bodies and foreign tastes are reduced to a minimum by means of activated carbon treatment, performed either by passing the solution through vessels filled with granular activated carbon or by suspending and subsequent filtering the activated carbon powder.

A finely tuned system of multiple effect plate type or falling film evaporators is deployed to concentrate the solution. It is heated by steam and powered by mechanical or thermal vapor re-compression, thus ensuring the greatest degree of energy efficiency in combination with minimal thermal stress for the product. The final dry substance content is adjusted to fit the market demand or the subsequent processing steps.

PRODUCT APPLICATIONS

High glucose syrup is commonly used as fermentation feedstock, and it serves as an intermediate to produce high fructose syrups or sorbitol. Crystallization of high glucose syrup yields dextrose anhydrate or monohydrate, both being used in foodstuff as a sweetening agent, and in medical applications. Hydrol, the mother liquor, is used as a feed additive.



AVERAGE CONSUMPTION FIGURES

Typical figures for 1,000 kg of end product

Parameter	Starch, DS	Steam	Power
Glucose syrup DE96 (75% DS)	710 kg	750 kg	60 kWh
Glucose monohydrate (91% DS)	1,250 kg	1,800 kg	460 kWh

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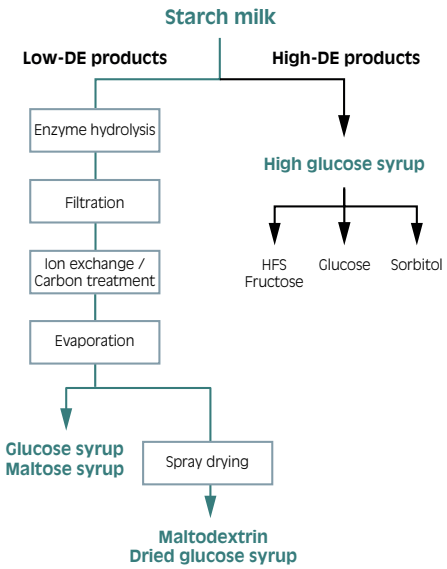
LOW-DE GLUCOSE AND MALTOSE SYRUP

CONVERSION

For low-DE sweeteners, the starch slurry is prepared as described above and, depending on the product, undergoes either a one-step or a two-step conversion by means of enzymatic hydrolysis.

In the liquefaction step, solutions with a DE below 20 are formed. For solutions higher than DE20, a second conversion step is carried out for saccharification.

Selected process parameters and enzymes ensure that the desired DE values and sugar profiles are achieved within a saccharification time of 10 – 30 hours. Once the specified value is reached, the enzymes are inactivated to stop reaction.



ENZYMES

The composition (sugar profile) of starch sweeteners is defined by the enzymatic conversion mode. The enzyme industry offers an extensive range of products for a variety of enzymatic reactions, which is constantly being expanded. The selection for each application is made with the involvement of the enzyme manufacturer, while Vogelbusch takes care of the corresponding equipment specification.

PURIFICATION

The filtration process to separate suspended solids such as fibers and proteins depends on the product range of the plant. Since syrups with DE values lower than 40 are highly viscous liquids, classical vacuum drum filters or sintered metal cross-flow membranes are chosen. For syrups with a DE value above 40 polymer or ceramic cross flow membrane filtration are also applied.

Ion exchange and activated carbon treatment to purify the filtered solution and evaporation for further concentration are applied in a similar way to high glucose syrup production described above.

As regards maltodextrin and dried glucose syrup production, the syrup is concentrated by a process of evaporation to 60-65% DS. In a spray dryer, the concentrated solution is atomized to fine droplets, which are sprayed into the drying chamber. Here the residual water is evaporated using hot air and the maltodextrin agglomerates. The granules are cooled, sifted, and packed.

PRODUCT APPLICATIONS

Glucose syrup, also known as corn syrup, is a liquid starch sweetener used for foods and beverages. Maltodextrin and other spray-dried glucose syrups are used in the instant food industry as an energy source, a flavor carrier and as a thickening agent.

AVERAGE CONSUMPTION FIGURES

Typical figures for 1,000 kg of end product

Parameter	Starch, DS	Steam	Power	Natural gas [2]
Glucose syrup DE63 (80% DS)	790 kg	860 kg	68 kWh	-
Maltose syrup DE40 (80% DS)	810 kg	860 kg	72 kWh	-
Maltodextrin DE20 (95% DS) [1]	990 kg	1,400 kg	370 kWh	90 Std.m³

[1] Energy figures including spray dryer
[2] Steam as alternative heat source for spray dryer possible

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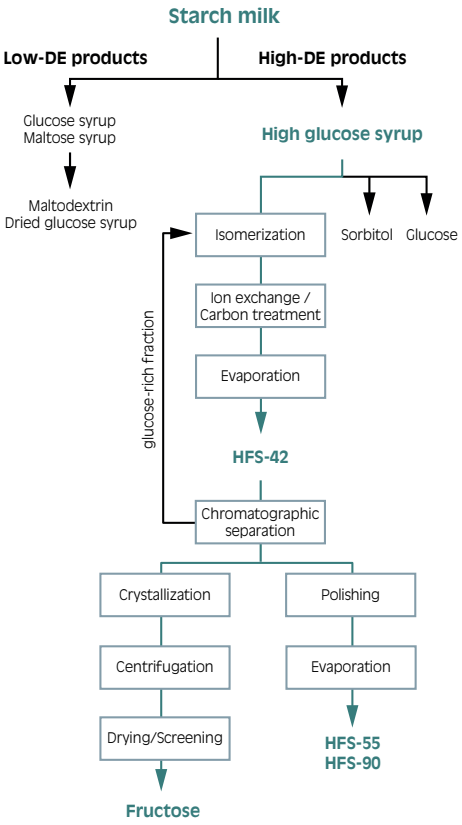
HIGH FRUCTOSE SYRUP – HFS

CONVERSION

HFS is made from high glucose syrup by converting some of its glucose into fructose by means of a third bioconversion step called isomerization.

The ion content of the syrup is adjusted by adding certain salts to extend the life of the enzymes used. The substrate passes through columns that are filled with the immobilized enzyme isomerase, creating a glucose-fructose syrup also known as isoglucose, with a concentration of approximately 42% fructose in dry matter substance (HFS-42).

Isomerization can be designed for contents up to 48% fructose in dry matter substance, for instance for producing high purity fructose products (HFS-98, crystalline fructose).



PURIFICATION

The isoglucose syrup undergoes a purification step including ion exchange and decolorization (activated carbon treatment).

In a continuous chromatographic separation process, the isoglucose syrup is separated in a fructose-rich (90 - 98% pure extract) and a glucose-rich (raffinate) fraction. While the raffinate is recycled to the isomerization process, the extract is blended with isoglucose syrup to reach the desired content of 55% fructose. After the solution has been polished in a mixed bed ion exchanger, the product is ultimately concentrated to 77% DS by means of multi-effect evaporation and marketed as HFS-55.

Alternatively, isoglucose syrup can be concentrated by evaporation to 71% DS and marketed as HFS-42.

PRODUCT APPLICATIONS

Both HFS-42 and HFS-55 are commonly used in food, beverage, and confectionery applications as in manufacturing the liquid product is easier to handle compared to crystalline sugar.
Besides being used to manufacture HFS-55, the extract from chromatographic separation can be marketed directly or subjected to further processing.
Typical applications include:

- Liquid sweetener with high fructose content
- Manufacture of crystalline fructose
- Feedstock for biotechnological or catalytic processes which need pure fructose

Our plants are designed to produce HFS according to ISBT standard, which incorporates the quality requirements of the biggest beverage producers.

AVERAGE CONSUMPTION FIGURES

Typical figures for 1,000 kg of end product

Parameter	Starch, DS	Steam	Power
HFS-55 (77% DS)	735 kg	1,100 kg	90 kWh
HFS-42 (71% DS)	680 kg	780 kg	70 kWh

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Starch sweeteners are made in both liquid and dry varieties.

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