Project Study for enzymatic Production of High Fructose Syrup (HFS)

2005

- **Foreword**

The food and drink industry depends heavily on enzymes. Enzymes produced by yeast have been used for thousands of years in brewing and baking.

High fructose syrup contains fructose and glucose in roughly equal proportions. The high fructose syrup is greater in demand than pure glucose as food and drink sweeteners, because fructose is sweeter than glucose. Therefore, if glucose can be converted into fructose, its commercial value is increased greatly.

High Fructose Syrup (HFS) is a concentrated solution containing fructose and dextrose with lesser quantities of higher molecular weight saccharide. It is extremely sweet and clear syrup, refined by carbon and ion exchange systems to assure the highest food standards in terms of colour, clarity, composition, flavour and ash. Therefore, it is rapidly developing as an alternative to cane sugar particularly in the case where the sugar is dissolved and filtered before being added to the formulation. High fructose corn syrup is a relatively new product, production of which started in 1966 in Japan, but popularised only after 1971 when the USA started its production. As the product is new to the market, its applications are not yet fully developed. Main consumers of HFS are the baking, beverages, canning, confectionery, dairy industries. In addition, high fructose syrup is used in many other processed foods like jams and jellies. However, it is being used only in biscuits and soft drinks. Manufacturers of HFS expect to supply it in next couple of years to the confectionery, fruit canning, processed foods and dairy products industries also.

Fructose, also known as fruit sugar, is the sweetest natural sugar and is found in fruits, vegetables, and honey.

The body responds to fructose in a different way than to glucose and sucrose. Fructose is more satiating, and it is up to 1.8 times sweeter than sucrose, making it useful in foods and beverages for the health conscious. Fructose is also ideal for use in diabetic foods as it has very little effect on blood glucose and only a negligible effect on the secretion of insulin.

As mentioned above, the principal use of glucose isomerase is in the production of high-fructose syrups from glucose syrups (which are themselves usually derived from maize or corn starch. Also possible with pure Glucose or Molasses).

Enzymatic treatments are a now a major way of producing sweeteners, including syrups derived from sucrose derived from sucrose or starch that contain mixtures of glucose, maltose, fructose, and other sugars. High fructose syrup (HFS) from maize starch has now eclipsed sucrose as the major sweetener used in US food industry.

For production of HFS it exist 3 production process with similar technology and pathway but three different start material:

1. Starch (the industrial sources is maize or other corns)
2. Molasses (from sugar cane or sugar beet)
3. Cellulose (it is in Pilot scale but successful Development)

Glucose has 70-75% the sweetening strength of beet sugar (sucrose), but fructose is twice as sweet as sucrose. Thus, processes for the manufacture of fructose are of considerable value.

- **High Fructose Syrup Production Pathway**

This chapter describes different pathways of fructose production in industrial scales with enzymes, which are involved in the HFS production with different start materials.

1. Starting with Starch
2. Starting with Molasses
3. Starting with Cellulose

- **Biochemical and Biotechnological Information**

The biochemical character of compounds, which are involved in the different processing is described and structured as followed:

The following biochemical data describes enzymes, which are involved in the HFS production from different start materials:

1. Starting with Starch
2. Starting with Molasses
3. Starting with Cellulose

- **Economical Data:**

Glucose has 70-75% the sweetening strength of beet sugar (sucrose), but fructose is twice as sweet as sucrose. Thus, processes for the manufacture of fructose are of considerable value. The commercial process for production of fructose from glucose became feasible only when procedures for immobilization of the enzyme were developed, so that the same batch of enzymes could be used repeatedly. Since glucose isomerase is formed intracellularly in most strains, many commercial processes are carried out with immobilized cells or by the addition of partly broken cells.
Syrup refineries produce a multitude of products by processing starch. The focus of this discussion is high fructose syrups that are used as sweeteners for a variety of products. These syrups have long been used as sweeteners in the beverage industry; the soft drink industry represents the largest consumer of these products. Sucrose is sweeter than dextrose, but less sweet than fructose; ideally, a mixture of half fructose and half dextrose would most closely mimic sugar. However, a blend of 55% fructose and 45% dextrose will most closely duplicate the flavour and mouth feel of the traditional beet and cane sugar.

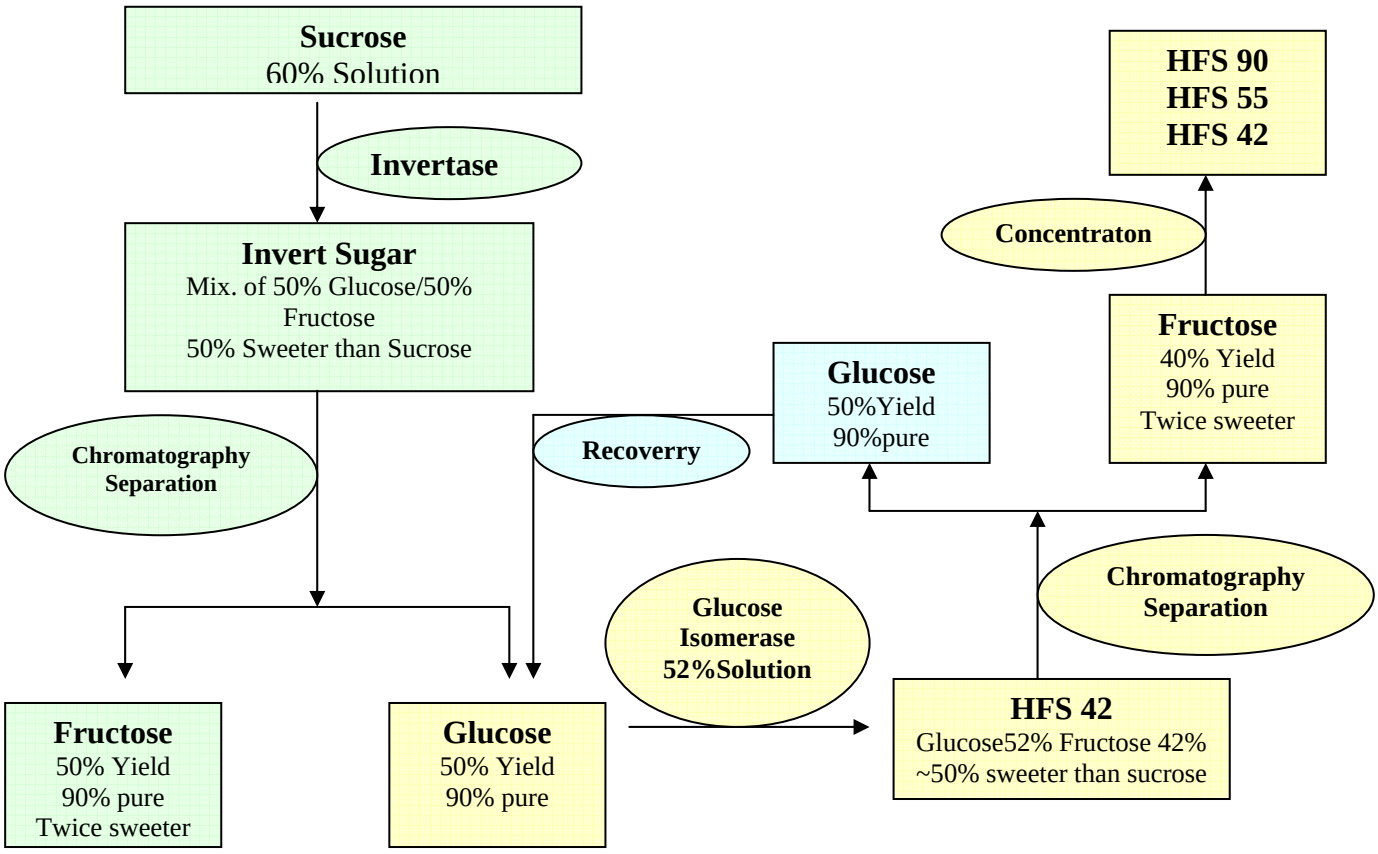
- **Process line**

Process part Molasses:

Process part Production invert sugar from sucrose:

Process part production fructose from glucose:

Process part chromatography(an model from Dow chemical industry):



- **Feasibility**

The investment is split in following parts:

This is the part which will be content of our possible quotation after the decision for the production of fructose (enzymatic process). Ensymm Company has the knowledge and qualified suppliers for the enzymatic part, chromatography and turn-key plants. All partners are German companies.
Please pay attention to the following calculation to get an overview on the investment difference between imported sugar and HFS from molasses (30% or 40% sucrose).

- **Operating costs:**

These are broken down in the raw materials, utilities and chemical consumption per ton of produced HFS as Dry Substance.

The bulk of the operating costs are in the Molasses costs, which typically represents the major part of the total operating costs (depend on sucrose weight in %.Please show calculation). The next greater cost is chemical cost at nearly 20 % of the total. This includes resins, enzymes and other processing chemicals; the bulk of the Chemicals are regeneration chemicals for ion exchange (hydrochloric acid and sodium hydroxide) and powdered carbon.
Utilities represent approximately 6% of the total operating costs. The product is typically loaded out into either rail cars or tank trucks.
This is a consumption figure per ton of produced HFS 55

- **Optimization**

- Using cheap molasses instead of import of expensive sugar
- All immobilised enzymes and chromatographic columns are for usage in multiple processing line and not in batch processing.

Commercial Report for purchasing is available

We thank you for your attention

looks forward to a fruitful co-operation

between your company and our network

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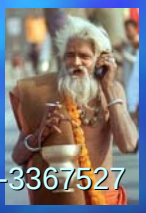

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