APPLICATION NOTE – DETERMINING INVERT SUGAR CONCENTRATION BY POLARIMETRY

Application Need: Producers of invert sugar for the food and beverage industries need to be able to determine invert sugar concentration. Inverting sugar in your own factory is a time-consuming process that needs critical process control, and can be difficult to manage in the busy production environment.

Solution: Use the Reichert Polar1 or Polar3 polarimeter to accurately determine invert sugar concentration.

Overview of Invert Sugar

Invert sugar is a mixture of equal parts glucose and fructose. It is found naturally in honey, and it is manufactured artificially as a sweetener for use in the baking, beverage, canning, confectionary, and dairy industries. Invert sugar is sometimes referred to as artificial honey, because its composition and properties are nearly the same as honey. Invert sugar is made from the hydrolysis of sucrose (beet sugar). Fructose is sweeter than pure sucrose, so invert sugar is in great demand, because manufacturers can use less of it to sweeten their products. Using less sweetener benefits both the manufacturer (lower costs) and the consumer (fewer calories).

Fructose, also known as fruit sugar, is the sweetest natural sugar. Fructose is found naturally in fruits, vegetables, and honey. Fructose is more satiating than either sucrose or glucose. It is up to 1.8 times sweeter than sucrose (and glucose is only about 70 to 75 percent as sweet as sucrose). Also, the human body responds differently to fructose than it does to glucose and sucrose, and because of this, fructose is ideal for use in diabetic foods, because it has very little effect on blood glucose, and only a negligible effect on the secretion of insulin. So fructose is a healthier alternative to either glucose or sucrose as a sweetener. Therefore, the process to manufacture fructose is very valuable to the food and beverage industries.

Why is it Called “Invert?”

Invert sugar is so-named because of the effect sucrose solutions have on polarized light when being analyzed by a polarimeter; compared to pure sucrose, a mixture of glucose and fructose "inverts" the plane of polarized light, and so it is known as invert sugar.

Uses for Invert Sugar

Invert sugar is used in many applications, including:

- **Cookies:** For caramelization, enhanced flavor, and better texture.
- **Breads, Cakes & Pastries:** For better crust color, softer crumbs, and faster yeast activation.
- **Fruit Processing:** For better shelf life due to good humectant properties; provides better taste profile and enhances flavor.
- **Honey:** For bee feeding and blending with honey. Has restricted bacterial activity. Chemically pure replacement of honey.
- **Juices, Lemonades, and Instant Energy Drinks:** For instant energy and better taste than artificial sweeteners.
- **Pharmaceuticals:** For use in cough syrups and glucose- and fructose-based intravenous fluids.

Whether you are making your own invert sugar or using a supplier's, you can measure and control the quality of the invert sugar using a Reichert polarimeter.

How Invert Sugar is Made

Traditionally, the method for manufacturing invert sugar involved acid hydrolysis of sucrose, which is a popular and cheap sweetener, into glucose (dextrose) and fructose. However, acid hydrolysis has a low conversion efficiency and high energy consumption, making the cost of production high. The acid-hydrolyzed product also contains impurities introduced by uncontrollable parameters during inversion.

A better method making invert sugar now uses **invertase**, an enzyme produced by yeast, to catalyze the hydrolysis of sucrose (this study discusses the substrate-induced changes by the yeast saccharomyces cerevisiae). The process of inverting sugar using invertase has a conversion efficiency of almost one hundred percent, with none of the disadvantages of acid hydrolysis. Enzymatic treatments are a now a common method of producing sweeteners, especially for the manufacture of candies and preserves, the production of lactic acid, and ethanol production from the fermentation of cane sugar molasses.

Controlling Sweetness Through Partial Inversion

Invert sugar is prepared by the hydrolysis of sucrose. Invert sugar syrups can be **fully inverted** (all of the sucrose is completely converted) or **partially inverted** (some of the original sugar is unchanged; also known as **medium invert** sugar syrup).

Medium invert syrup (which contains 50 percent sugar, 50 percent invert) is 20 percent sweeter than either pure sugar or pure invert. Therefore, manufacturers can use almost 20 percent less sweetener if they replace ordinary sugar with medium invert. Use of a polarimeter helps accurately produce the desired ratio of invert sugar to sugar.

Sucrose Inversion Using Invertase

The key to the enzyme-based inversion process is a specific enzyme for the continuous production of concentrated invert sugar. The process uses immobilized yeast cells in an inorganic, insoluble matrix.

Enzyme-based inversion has several advantages over the hot acid process:

- Near 100 percent yield
- Requires low temperature (low energy cost)
- No impurity
- 1:1000 dosage
- Better taste of product
- Easy handling
- Small stock

Enzyme-based inversion is more expensive than the acid method, but is a better alternative, as it does not produce any polymerized byproducts. Yeast cells are commonly used as a source of invertase. Inversion studies were carried out either by using free yeast cells or immobilized cells of the enzyme invertase. The yields obtained using immobilized cells are generally low, due to steric hindrances. Yields are much higher using free cells that can be easily filtered on a membrane module. The enzyme-based inversion of sucrose is therefore performed on a membrane bioreactor. Experimental results indicate that there is a 100 percent conversion of 30 percent weight/volume aqueous solution of sucrose within 30 minutes of the yeast loading of 1 percent weight/volume, at both 35° C and 65° C. The yield of the reducing sugar was also 100 percent.

Summary

Invert sugars and high-fructose syrups have many advantages, such as taste, flavor, and texture. Enzymatically inverted sugar does not involve the use of any chemicals or acids, unlike the conventional acid-hydrolyzed invert

syrup, which makes enzymatically-inverted sugars a healthier sweetener. Manufacturers can use almost 20 percent less sweetener if they replace ordinary sugar with medium invert, as well, which benefits both the manufacturer (lower costs) and the consumer (fewer calories). Reichert Polarimeters are used during the inversion process to monitor quality, and also by manufacturers to verify incoming materials and to control final product quality.

Product Recommendations:

Polar3 Polarimeter – Reichert Cat #14003000

Polar1 Polarimeter – Reichert Cat #14001000