Extraction of Glucose Syrup from Tapioca Starch

Hymavathi Darla[1]

[1]Chemical Engineering Laboratories, College of Engineering, Sri Venkateswara University, Tirupati, India.

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ABSTRACT

Tapioca starch, a near-pure carbohydrate derived from the roots of the cassava plant (*Manihot esculenta*), is a globally significant ingredient with diverse applications.

Extracted through a process of grinding, washing, and drying the cassava root pulp, it presents as a fine, white powder characterized by its neutral flavour, odour, and ability to form clear, viscous solutions and gels upon heating. Its inherent gluten-free nature has propelled its widespread use in gluten-free baking and food formulations, providing binding, textural enhancement, and moisture retention.

Tapioca starch serves as a crucial raw material in various industries-adhesives, paper manufacturing, textiles, pharmaceuticals, and the production of sweeteners and biodegradable materials and nutritionally lean, its unique functional properties- thickening power, freeze-thaw stability, and film-forming capabilities, is an indispensable component in numerous food and industrial processes, contributing significantly to both food security in tropical regions and the global market for specialized starches.

The moisture content in the glucose is 16.5%, and the ash content of the tapioca starch is 34.66% and overall yield of the glucose syrup using tapioca starch is the 78grams.

Keywords: Tapioca; Cassava; Starch; and Glucose Syrup.

INTRODUCTION

The glucose level of cassava peel and pulp and the effect of enzyme variation on the glucose yield were determined using enzyme hydrolysis method. Parameters measured include pH, glucose concentration and total dissolved solids known as brix. A total of nine samples were used; three each from the cassava peel, pulp, and pure starch. The enzyme concentrations were 20/IU/L, 30/IU/L and 40/IU/L for the three-feed stock at a constant value. The brix decreased as the quantity of enzymes used for the hydrolysis increased for all the feedstock used. When the enzyme concentration was 20/IU/L, the glucose yield for the cassava peel, pulp, and pure starch were 3.76mg/ml, 6.16mg/ml and 7.20mg/ml respectively; whereas the concentration of glucose at the same enzyme concentration of 30/IU/L was 4.00mg/ml, 6.98mg/ml and 7.56mg/ml respectively. At 40/IU/L enzyme level, the glucose yields were 4.25mg/ml, 7.14mg/ml and 8.22mg/ml. The pH slightly increased with increase in enzyme concentration. Cassava peels yielded a substantial amount of glucose with adequate amount of enzyme, although slightly lower than that of the pulp. Hence, cassava peels, Emma Z.N and Sari M. G(2024) can be used to make glucose syrup that could be used as food additives.

Glucose syrup, also known as corn syrup when derived from maize, is a concentrated aqueous solution of glucose and other carbohydrates, obtained by the hydrolysis of starch. Tapioca starch, derived from the cassava plant peel (*Manihot esculenta*), as a promising alternative to maize starch due to its high starch content, low cost, and wide availability in tropical regions.

Tapioca starch is rich in amylose and amylopectin, making it highly suitable for enzymatic hydrolysis. Studies, Fatai A. A, et al. (2024) highlight the high purity and excellent gel-forming characteristics of tapioca starch,

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which improve the efficiency of hydrolysis. There are two primary methods used to hydrolyze starch into glucose syrup, acid hydrolysis was the first method used industrially involving hydrochloric acid and this method lacks to undesired by-products and darker syrup. Acid hydrolysis is cost-effective, suffers from lower yields and environmental concerns due to corrosion and disposal issues Agi, A., et al. (2017). Recent techniques favor enzymatic hydrolysis, which involves two key enzymes: α-amylase: breaks down starch into dextrins, Glucoamylase (amyloglucosidase), further breaks dextrin's into glucose research by Musdalifa, M., Laga, A. & Rahman, A.N.F. (2024) demonstrates that enzymatic hydrolysis using *Aspergillus niger*-derived enzymes offers higher yields, better control, and higher purity syrup. Optimal conditions such as pH (5.0–6.5), temperature (55–60°C), and time significantly impact the efficiency of hydrolysis. Process optimizing reaction parameters, Hymavathi, D and Prabhakar, G. (2017) - enzyme concentration, reaction time, temperature using Response Surface Methodology (RSM), Hymavathi, D and Prabhakar, G. (2018) to maximize glucose yield by Madara D.W. Samaranayake et al. (2017). Usually measured using DNS (3, 5-dinitrosalicylic acid) assay. Madara D.W. Samaranayake et al. (2017) conducted comparative studies showing that tapioca-derived glucose syrup can match or exceed the quality of corn-based syrup in sweetness and clarity, Kamaljit K et al. (2016).

Tapioca roots were peeled, washed and disintegrated in a grating machine. The resulting tapioca mesh was reground and mixed with water in the ratio 1:5 (w/v %). The mesh was filtered through double layer of nylon cloth to obtain starch solution. The starch was separated from the water by sedimentation and decantation.

MATERIALS AND METHODS

Equipment

In this study, the tools used were a set of glassware, blender, analytical balance, hot plate, pH meter, refrigerator, cuvette, filter, magnetic bar, UV-visible equipment, Hitachi brand centrifuge, FT-IR equipment.

Materials

Materials used in this study were Tapioca starch, Cassava Peel(s), NaCl(s), $BaCl_2$(s), $(NH_4).2SO_4$(s), Phosphate buffer(aq), $NaH_2PO_4.H_2O$(s), Na_2HPO_4(s), NaOH(s), H_2SO_4(p), $CuSO_4.5H_2O$(s), $KNaC_4H_4O_6.4H_2O$(s), $Na_2HASO_4.7H_2O$(s), Iodine(s), Starch Indicator(s)

Tapioca Starch Preparation

Tapioca starch was prepared following the method of E. Rohman et al. (2021**)**, Tapioca roots were peeled, washed and disintegrated in a grating machine. The resulting tapioca mesh was reground and mixed with water in the ratio 1:5 (w/v %). The mesh was filtered through double layer of nylon cloth to obtain starch solution. The starch was separated from the water by sedimentation and decantation, Kristianingrum S et al. (2021). The starch was set in an oven to dry and starch used in a several dishes. The native starch as shown in figure 1.

Figure 1: Starch powder

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Tapioca starch is used in a vegan kitchen because of it is a plant-based ingredient and it can made at home due to effortless and straight forward.

Dehydrate Tapioca Starch

There are two ways of dehydrating the residue to get tapioca starch- a quick way to dehydrate residue to get starch, place the breaking tray in a dehydrator for about 12 to 20 hrs at 120^{o}F and another way of dehydrating residue is by placing the baking tray in an oven at 225^{o}F for about 2 hours.

Tapioca Starch Used

It is most commonly used to press clothes to get the perfect crease. Mix it in water to make a slurry and store it in a shower bottle. Spray it on clothes and press to get a crisp cloth. It is most widely used to coat chicken or fish for frying. You can also create a batter out of tapioca starch. Frying it will give you a crispy texture. It is also a thickening agent in stews and soups. You can mix it with water to create a slurry. It helps to thicken up the soup and stews. It is also used in baking. You can make delicious dessert mocha is made using tapioca starch. Can also create noodles from tapioca starch. It is also used for making boba. It is also used to make pancakes, tortillas, bread, cookies, and pudding. There are several benefits of using tapioca starch. These benefits are because tapioca starch is having high carbohydrates content and low protein content. Furthermore, it is also a gluten-free flour making it safe for those who have gluten allergies.

Preparation Of Alpha Amylase Enzyme from different fruits

Mangoes are a juicy tropical fruit that is popular in summer. They contain the digestive enzymes a group of enzymes that break down carbs from starch (a complex carb) into sugars like glucose and maltose. The amylase enzymes in mangoes become more active as the fruit ripens. Amylase enzymes are also made by the pancreas and salivary glands. They help break down carbs so that they are easily absorbed by the body. That's why it's often recommended to chew food thoroughly before swallowing, as amylase enzymes in saliva help break down carbs for easier digestion and absorption.

Bananas are another fruit that contains natural digestive enzymes, Nkhata S.G et al. (2018). They contain amylases and glucosidases, two groups of enzymes that break down complex carbs like starch into smaller and more easily absorbed sugars. Like mangoes, these enzymes break down starch into sugars as bananas start to ripen. That's why ripe yellow bananas are much sweeter than unripe green banana. On top of their enzyme content, bananas are a great source of dietary fiber, which may aid digestive health. A medium banana (118 grams) provides 3.1 grams of fiber. A two-month study in 34 women looked at the connection between eating bananas and the growth of healthy gut bacteria. Women who ate two bananas daily experienced a modest, non-significant rise in healthy gut bacteria. However, they did experience significantly less bloating.

Preparation of substrate:

Banana peel used as substrate was obtained from fruit market and chopped into small pieces of uniform size and stored in polythene bags at room temperature.

Solid state fermentation:

1. In 250ml conical flask banana peel is chopped into pieces (10gm) and it is heated at 90 degrees in a heater.
2. 1ml of the inoculums is added and is incubated at 37^{o}C for 24 hours.
3. The cultivation of micro-organisms on moist solid supports, either on inert carriers or on insoluble substrates that can, in addition, be used as carbon and energy source.
4. It holds tremendous potential for the production of alpha amylase.

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5. The fermentation takes place in the absence or near absence of free water, thus being close to the natural environment to which micro-organisms are adapted.

6. The growth of the bacillus subtilis on the banana peel is observed.

Chemical Analysis

After extraction and modification of native starch, some chemical tests were performed to confirm any improvements in quantity of modified starch.

- Iodine colour reaction
- Moisture content
- Ash content
- pH
- Gelatinization temperature

RESULTS AND DISCUSSIONS

Yield of Glucose Syrup

The enzymatic hydrolysis of tapioca starch produced a glucose syrup yield of approximately 75%–85%, depending on the enzyme concentration and hydrolysis time. The highest yield was obtained at temperature 60°C, of pH 5.5, of hydrolysis time at 4 hr and at enzyme concentration: 0.6% (v/w starch), F. Nsanzabera et al. (2023).

Dextrose Equivalent (DE)

The DE values ranged from 40% to 95%, increasing with hydrolysis time. Syrup with DE above 60% indicated a high level of starch breakdown into glucose, suitable for use as a sweetener in food and beverage industries.

Viscosity and Clarity

The final syrup had a low viscosity and high clarity, suggesting effective hydrolysis and filtration. Syrup produced under optimal conditions had a light-yellow colour and transparent appearance.

Reducing Sugar Content

Using the DNS assay, the glucose content was found to increase steadily during hydrolysis. Maximum reducing sugar content was recorded at the 4-hour mark, aligning with the peak DE value.

Comparison with Corn Syrup

When compared with commercial corn syrup, the tapioca-based syrup shows the following parameter changes-comparable sweetness, slightly lower viscosity and better colour clarity. These characteristics make tapioca syrup a strong alternative in confectionery and beverage industries.

Procedure for determination of Ash content.

1. Take 1.5g of starch sample was weighed into a dish of known weight

2. The dish was put into a furnace temperature 900^{o}c and the sample left to ash.

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3. After ash the sample, the dish was brought out of the furnace, cooled of the sample was calculated.

Formula for calculation of ash content.

$$\% \text{ Ash Content} = \frac{\text{Weight of ash} - \text{weight of empty dish}}{\text{Weight of sample}} \text{X100}$$

CONCLUSION

Glucose syrup, derived from tapioca starch, is a versatile sweetener used in various food and beverages products. It is made by extracting starch, from tapioca, then breaking it down into simpler sugars using enzymes. The resulting liquid is filtered to remove impurities and then evaporated to achieve the desired concentration. Glucose syrup serves as a source of energy and sweetness in many food applications, such as confectionery, baked goods, and beverages. Its thickening properties also make it useful in certain recipes. By using amylase enzyme, glucose syrup containing over 50% maltose, or even over 70% maltose can be produced. The moisture content in the glucose is 16.5%, and the ash content of the tapioca starch is 34.66% and overall yield of the glucose syrup is the 78grams. The overall glucose syrup from tapioca starch is a widely utilized ingredient in the food industry.

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