Financial Feasibility of Liquid Sugar Production from Sago Starch with Enzymatic Hydrolysis Method

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Abstract. The objective of this research was to analyse the feasibility of processing sago starch into liquid sugar product with enzymatic hydrolysis method on the pilot plant scale. Optimization of the production process is carried out by enzymatic hydrolysis with the conditions of the ratio of starch and water is 1:4, the process of liquidation at 90°C for 90 minutes with the addition of the enzyme α-amylase 1.2 mL kg\(^{-1}\) at pH conditions of 5. Saccharification process with the addition of the enzyme glucoamylase 1.2 mL kg\(^{-1}\) starch at pH 4.5 and temperature 50°C for 72 hours, purification with an ion exchange resin and evaporation with a vacuum evaporator at a pressure of 0.4 atm at 80°C for 90 minutes. Financial analysis was based on the prevailing price in ten years showed that the processing sago starch into liquid sugar product with enzymatic hydrolysis method is viable and profitable as shown by BCR 1.16, NPV of Rp\(58,754,955.64\), PBP 2 years 11 months, and IRR 34.73%.

1. Introduction
The Indonesian Sugar Association (ISA) Data in 2017 [1] showed that domestic sugar production declined in the last three years. In 2016, national sugar production is only 2.2 million tons, while national sugar needs to reach 5.7 million tons. The difference between the need and realization of this production resulted in the increasing import rate of crude sugar reaching 3.2 million tons. Production realization and import of national sugar are presented in Table 1.

| Year | Total productions (tons) | Total imports (tons) |
|------|--------------------------|---------------------|
| 2012 | 2.6 million              | 2.3 million         |
| 2013 | 2.3 million              | 2.2 million         |
| 2014 | 2.6 million              | 2.8 million         |
| 2015 | 2.5 million              | 3.1 million         |
| 2016 | 2.2 million              | 3.2 million         |

Source: The Indonesian Sugar Association, 2017

The development of alternative sweetener materials to meet the needs of national sugar becomes one of the solutions to suppress import figures. Liquid sugar made from sago starch becomes one of the potential alternatives to be developed. The potential production of sago in Indonesia is estimated at 2 million tons per year or about 50 percent of the world's sago production [2]. The food and beverage
industry today has a tendency to use liquid sugar because of its advantages such as improving taste, appearance, consistency, longevity, and high levels of security. The problem in the production of liquid sugar today is the color of the liquid sugar produced in yellow or reddish yellow and the development is still in the laboratory scale. Thus, the optimization of the liquid sugar making process is done by means of the enzymatic hydrolysis process and modification of purification methods using ion exchange resin (anion-cation) so that the clarity of the liquid sugar color produced in accordance with SNI 01-2978-1992. Further evaluation of financial aspects is required to estimate the amount of investment funds required and whether the activity is profitable or not [3]. This research aims to analyze the financial feasibility of the selected optimisation process to be developed into the pilot plant scale as a representation in the development of the next industry.

2. Research Methods

2.1. Materials
The material used for the optimization of production processes is sago starch (Metroxylon sp.) produced from the Koto Marapak region, Pariaman, West Sumatra, Aquadest, α-amylase enzyme, glucoamylase enzyme, activated charcoal, filter paper and ion resin cation type Lewatit, CH₃COOH 30%, solution NaOH 30%, solution CaCO₃ 5% and solution H₃PO₄ 15%.

2.2. Equipment
The tools used for optimization of the production process are liquid sugar reactors, magnetic stirrer hotplates, stoves, pans, shaker baths, glassware, analytical scales, vacuum pumps, pH meters and thermometers.

2.3 Methodology
This research has been conducted in April-August 2019 which includes three phases. The first phase is to optimize the process of liquid sugar products in laboratory scale. The second phase is to test the product characteristics or quality of the resulting liquid sugar. The third stage is the feasibility analysis of financial aspects which include the calculation of net present value, internal rate of return, net benefit cost ratio, breakeven point, payback period, and sensitivity analysis to the price increase of raw materials and the decrease in the selling price of products.

3. Result and Discussions
The data presented is part of the research that has been conducted, and the discussion is focused on the aspect of financial feasibility.

3.1. Process optimization
At this stage, the production process is selected producing the best liquid sugar characteristics. The process stages are done by modifying some previous research [4]. Optimization of the production process of liquid sugar made from selected sago starch, which is the process of hydrolysis enzymatic with the comparison condition of starch and water is 1:4, the process of liquidation at 90°C for 90 minutes with the addition of α-amylase enzyme 1.2 mL kg⁻¹ and condition pH 5. The process of saccharification with the addition of glucoamylase enzyme 1.2 mL kg⁻¹ starch at pH 4.5 and temperature 50°C for 72 hours, purification with ion exchange resin and evaporation using vacuum evaporator at pressure 0.4 atm temperature 80°C for 90 minutes. The process of optimizing liquid sugar manufacturing processes [4, 5] modified in Figure 1.

3.2. Product characterization (quality testing of liquid sugar)
The resulting sugar product is tested for its quality through organoleptic tests including flavor and aroma, as well as a physical characteristic test that includes total dissolved/° Brix solids (refractometers), pH values, turbidity, total sugar levels and color measurements (chromameter). Chemical characteristics are with the parameters of water content test (SNI 01-2891-1992), ash content (SNI 01-2891-1992), reducing sugar levels (SNI 01-2891-1992) and metal content (Pb, Cu, Zn, As) (SNI 2354.5:2011).
Microbiological characteristics include Total plate number (ALT) test (ISO 4833:2003), mold and yeast (FDA-BAM 2001). The physical characteristics of the resulting liquid sugar test are shown in Table 2.

**Figure 1.** Optimization production of liquid sugar with enzymatic hydrolysis method

| No  | Treatment                                | Viscosity (°Brix) | Turbidity NTU | Color (°h) | pH  |
|-----|------------------------------------------|-------------------|---------------|------------|-----|
| 1   | Liquid sugar reference                   | 80.00             | 1.09          | 98a        | 6.8 |
| 2   | Liquid sugar before purification         | 30.55             | 1.61          | 73a        | 5.0 |
| 3   | Purification with activated charcoal     | 60.82             | 9.28          | 62a        | 7.2 |
| 4   | Purification with resin                  | 65.75             | 1.30          | 93a        | 7.0 |

Based on the analysis of physical characteristics of liquid sugar in Table 2, the optimal process of making liquid sugar uses ion exchanger resin. The resulting yield is 80%.
3.3 Financial Feasibility Analysis
The criteria used in the financial aspect feasibility analysis include net present value, internal rate of return, net benefit cost ratio, and payback period. These criteria are used to look at financial industry feasibility. The calculations of these criteria are based on net cash flow on the projected cash flows. The discount factor used is 14 percent. Details on the investment eligibility calculation can be seen in Table 3.

**Table 3. Investment Feasibility**

| Year | Bt-Ct (IDR) | Accumulation (IDR) | DF | PV (IDR) | Cumulative PV |
|------|-------------|--------------------|----|----------|---------------|
| 0    | -380,779,000 | -380,779,000       | 1,000000 | -380,779,000.00 | -380,779,000.00 |
| 1    | 127,956,181       | -252,822,819 | 0,769231 | 98,427,831.69 | -282,351,168.31 |
| 2    | 127,956,181       | -124,866,638 | 0,591716 | 75,713,716.69 | -206,637,451.62 |
| 3    | 127,956,181       | 3,089,544        | 0,455166 | 58,241,320.53 | -148,396,131.09 |
| 4    | 127,956,181       | 131,045,725      | 0,350128 | 44,801,015.79 | -103,595,115.30 |
| 5    | 128,711,181       | 259,756,906      | 0,269329 | 34,665,663.29 | -68,929,452.01 |
| 6    | 120,406,181       | 380,163,087      | 0,207176 | 24,945,296.41 | -43,984,155.61 |
| 7    | 127,956,181       | 508,119,268      | 0,159366 | 20,391,905.23 | -23,592,250.38 |
| 8    | 127,956,181       | 636,075,450      | 0,122589 | 15,686,080.95 | -7,906,169.43 |
| 9    | 127,956,181       | 764,031,631      | 0,094300 | 12,066,216.11 | 4,160,046.68 |
| 10   | 752,637,181       | 1,516,668,812    | 0,072538 | 54,594,908.96 | 58,754,955.64 |

NPV 58,754,955.64
Payback period 2.97
IRR 34.73%
Net B/C 1.16

3.3.1 Net Present Value (NPV)
Net present value (NPV) is a method to calculate the difference between the present value of investment and the value of net cash acceptance (operational and cash flow terminal) in the future at a certain interest rate [6]. Eligibility requirements if NPV > 1 then investment is feasible. This method is calculated by the formula:

\[
NPV = \sum_{t=0}^{n} \frac{Bt-Ct}{(1+i)^t}
\]

(1)

Description:
Bt = Profit in the year to
Ct = Cost in the year to
i = Interest (%)
T = Investment period (t=0,1,2,3,...,n)
n = Economical age project

Based on Table 3, calculation of investment eligibility by making assumptions 10 years project life, production capacity is 150 kg/day, and the selling price of products IDR 10,000/kg, then NPV value in the liquid sugar industry is IDR 58,754,955.64. So the establishment of the liquid sugar industry sago starch is worthy based on NPV value.

3.3.2 Internal Rate of Return (IRR)
The Internal rate of return (IRR) is the interest rate at the time NPV equals zero and is expressed in percent (Gray et al., 1993). The project is worth running when the IRR value is greater than or equal to that of the prevailing interest rate. The interest rate used in this study was 14 percent. IRR can be calculated by formula:
\[ IRR = i(+) + \frac{NPV(+) - NPV(-)}{NPV(+) - NPV(-)} [i(-) - i(+)] \] (2)

Description:
NPV(+) = NPV Positively valued 
NPV(-) = NPV Negatively valued 
i(+) = Interest rates that make NPV positive 
i(-) = Interest rates that make negative NPV 

Interest rates based on Table 3. The calculation of investment feasibility, IRR in this liquid sugar industry is 34.73%. According to the IRR criteria, the liquid sugar industry is worthy to be established. The IRR value indicates a high enough value compared to prevailing interest rates. So it is very likely that capital financing is funded by outside parties, both investors and banking.

3.3.3 Benefit Cost Ratio (BCR)
Net benefit cost ratio (BCR) is a number of comparisons between the amount of present value which is positive value and present value which is negative value (investment capital). The calculation of BCR is done to see how many times the benefit gained from the cost incurred [7]. If BCR is worth more than one, it means NPV > 0 and the project is worth running. If the BCR is less than one, then the project should not be executed [8]. BCR can be calculated with the formula:

\[ BCR = \frac{\sum_{t=1}^{n} BL-Ct}{\sum_{t=1}^{n} BL-Ct} \] (3)

Based on Table 3. investment feasibility calculation, BCR value in this liquid sugar industry is 1.16. This means that, according to the criteria BCR, the industry is worthy to be established.

3.3.4 Payback Period (PBP)
The payback period (PBP) is the time period necessary to return the entire investment issued to the establishment of a business. PBP is calculated based on net cash flows. Based on calculation results from Table 3, PBP's liquid sugar industry is 2.97 years old. This means that all investments issued for the establishment of this industry will be back after 2.97 years of industry operation. Based on these PBP criteria, the liquid sugar industry is worthy to be established because the value of PBP is less than the project life of 10 years.

3.3.5 Sensitivity Analysis
Sensitivity analysis is conducted to examine the extent to which the financial aspect parameter changes affect the chosen decision. Sensitivity analysis on the establishment of the liquid sugar industry is done in two parameters, namely increase in the price of raw materials and decrease in product prices. The results of sensitivity analysis in this industry can be seen in Table 4.

| Table 4. Analysis of industrial sensitivity of sugar liquid starch sago |
|---------------------------------|-----------|-----------|-----------|-----------|
| **Sensitivity Parameter**       | **Investment Eligibility Criteria** |
| Raw material price rises 16.67% to IDR 3,500/kg | NPV (IDR) | IRR (%) | Net B/C | PBP (Year) |
| -10,609,916.10                  | 9.01%     | 0.97     | 3.61     |
| Product sale price drops 5% to Rp 9,500/kg | 3,263,058.25 | 15.29%   | 1.01     | 3.46     |

The result of analysis shown the increase of raw material and the decrease in the selling price of the product has its own effect for the sago liquid sugar industry. The results of sensitivity analysis to the parameter of the price decrease of product sell showed liquid sugar industry sago have a highest risk and impact on industrial losses. Therefore, if there is a rise in the price of raw materials or a decrease in
the selling price, it takes various adjustments and strategies to handle it so that the sago liquid sugar industry remains profitable.

4. Conclusion
The production process optimization of sago starch liquid sugar that will be developed to the plant scale is hydrolyzed enzymatically with the purification of ion exchange resin to produce a more white color characteristics and total yield 80%. Feasibility analysis of financial aspects assuming the production capacity of 150 kg/day, 10 years project life, product sales price IDR 10,000/kg showed that the liquid sugar industry of sago starch is worth running and have the opportunity to gain profit.

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