THE CHARACTERISTICS OF THE ARROWROOT STARCH AND ITS USE AS THE SOURCE OF RAW MATERIAL FOR GLUCOSE SYRUPS

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Abstract

The creation on productive activities to over come the monetary crisis prevailing in Indonesia and also to increase the social income is a must. For that purpose, the government has launched efforts related to the use of the carbohydrates in the arrowroot plant (Maranta arudinacea L). This type of plant has long been known by rural societies in Central Java and East Java. The people use its starch for traditional food. The Aim of this research is to investigate the characteristics of the Arrowroot starch and the factors affecting enzymatic hydrolysis of the starch, i.e.: the effect of substrate concentration and enzyme concentration on its liquefaction, the effect of saccharification. The experimental design used was a completely randomized factorial design. The result showed that the optimal condition of enzymatic hydrolysis was on the concentration substrate of 30%, α-amylase 53,913.42 U/kg substrate at 72 hours of saccharification by amyloglucosidase 60,319.28 U/kg substrate. The rendement of glucose syrup was 85.31% and DE 86.09.

Keywords: *Arrowroot, Starch, Glucose syrups*

Introduction

The monetary crisis prevailing in Indonesia at this time requires the creation of productive activities to increase social income. For the purpose, the government has launched efforts related to the use of carbohydrates in Indonesia. One of the alternative sources of carbohydrate developed is the arrowroot plant (Maranta arudinacea L). This type of plant has long been known by the rural societies in Central Java and East Java, whose people use its starch for traditional food. The advantage of the arrowroot as one of the sources of carbohydrates is among others as follows: it is easy to rear, the seedling grows on the root cut, and it can live under bare sunlight or even under sun light protection. The program to develop this plant until the year 2000 is to plant the arrowroot covering over 300,000 hectares area (which is equal to 900,000 tons of arrowroot starch). As soon as this arrowroot plant is fully developed, it is hoped to be useful as raw material as well as industrial commodity based on carbohydrate. One of the potential industries using arrowroot starch is glucose syrups industry.

The Department of Trade and Industry's data shows that utilization of national capacity industry of glucose has just reached 60%. Glucose import in 1996 was 112,396 kg or $ 98,419 worth. Most of the raw material used was tapioca and corn flour. The industries

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utilizing glucose are among others candy industry, beverage industry, and biscuit industry. The problem faced by the glucose industry at the moment is the supply of material and fluctuation of its price.

Based on the problem above, in order to anticipate the overflow of the arrowroot harvest during the years to come, a research is developed to investigate the characteristics of the arrowroot starch and its further process to become glucose syrups. This use is hoped to increase the farmer's additional income.

Methodology

This research was carried out in the Laboratory of the Research Institute of Biotechnology and Crops in Bogor. A survey of the form of the starch particles was done in the Institute of Veterinarian Research in Bogor, ad the characteristics of starch with amylograph in the Research Institute of crop at Sukamandi. The arrowroot starch used as a sample was taken from Malang, East Java, whereas the tapioca was from Bogor. The analysis of the arrowroot applied involved the content of water, protein, fiber, starch, and ash (AOAC, 1984). The measurement of enzyme (Bernfeld, 1975) and specific activities (Lowrey et. al 1975), sugar as the product of hydrolyzed starch was by the DNS method and the total solidified glucose (AOAC, 1984).

The experiment on the enzymatic hydrolysis of the arrowroot starch into glucose syrups on the substrate concentration level (20, 25, 30, 35 %) and the alpha-amylase enzyme concentration (1,797.114 U/kg substrate, 35.942.28 U/kg substrate, 53.913.42 U/kg substrate, 71.885.56 U/kg substrate) at liquefaction stage. The optimum result at the liquefaction stage was used to condition the saccharification at the saccharification time (48, 60, 72, and 84 hours) and the concentration of amyloglucocidase enzyme (43,083.20 U/kg substrate: 51,702.24 U/kg substrate: 60.319.28 U/kg substrate: 68.936.32 U/kg substrate). The experimental design used was a complete randomized design factorial 4 x 4 with a two replication, continued with a t-test to see the difference between the treatments.

The Result of The Research

The result of the characterization of the arrowroot starch was meant as additional information about the nature of the arrowroot starch, and t complete the data concerning starch. Observation about the granule of the arrowroot starch is oval, which of tapioca is round and the sago starch is not orderly. Based of the observation of the characteristics of amylograph starch, data were found that gelatinizing points of the arrowroot, tapioca and arrowroot were correspondingly 66.75 °C, 64.50 °C, and 67.50 °C. The lower the gelatinizing temperature, the shorter was the gelatinizing time. Gelatinizing time of the arrowroot starch was 24.50 minutes, that of tapioca was 23.00 minutes, and that of sago was 25.00 minutes. The broken granular of the arrowroot starch was 71.25 °C, that of tapioca was 84.00 °C, and that of sago was 73.50 °C. the time needed to break the granule for the arrowroot was 27.50 minutes, for tapioca was 36.00 minutes, and for sago 29.00 minutes. The viscosity of the arrowroot, tapioca, and sago were correspondingly 430 BU, 630 BU and 520 BU, and the cold viscosity (50 °C) was 200 BU, 460 BU and 480 BU.

The observation on the chemical components of the arrowroot, tapioca, and sago starch can be seen in Table 1 below :

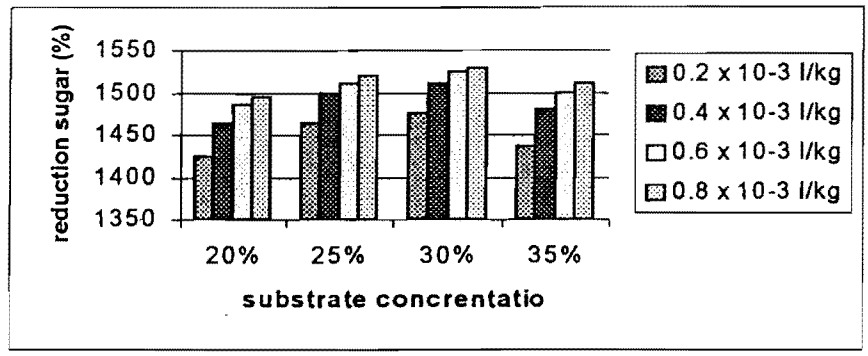

Figure 1.
The pattern of reduction sugar on different substrate concentration levels with different enzymatic concentration of alpha-amylase

According to Fogarty (1983) transglucocydase is an enzyme, which contains enzymatic amyloglucicydase and catalyzes the formation of saccharification. In this case, the purity of enzymatic amyloglucocidase very much influences on the product formation. The main product of backward reaction was maltose and isomaltose. The figure indicating the relationship between the products of reaction sugar at various time of saccharification can be seen in Figure 2 below.

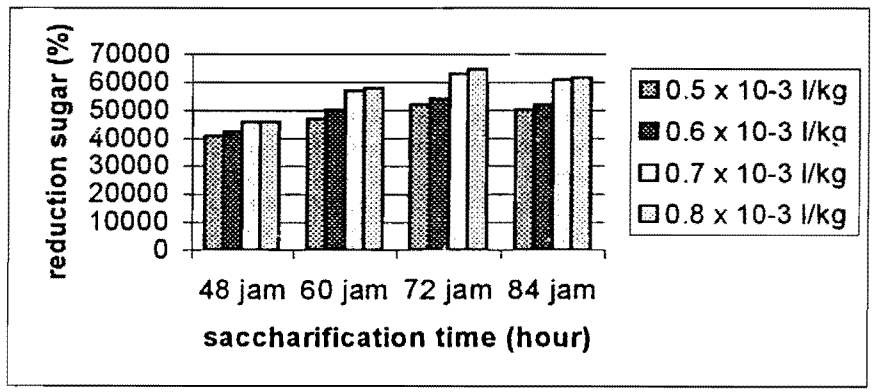

Figure 2.
Relationships between saccharification time and reduction sugar at various concentrations of amyloglucocidase

The treatment of saccharification time of 72 hours with a concentration of enzymatic amyloglucocidase 60,319.28 U/kg substrate and 68,936.32 U/kg substrate resulted in high

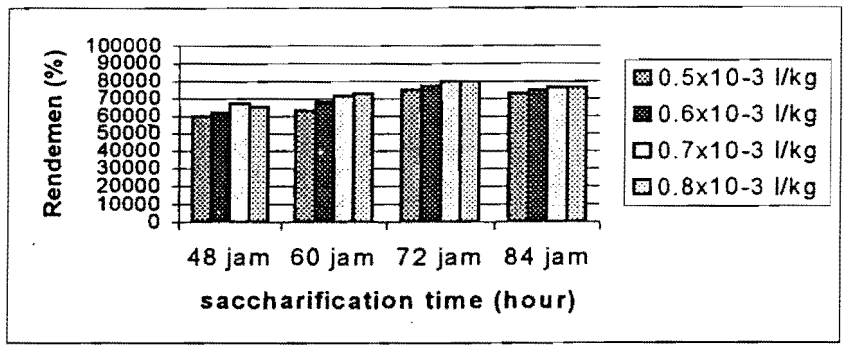

Figure 4. Relationships between Observation on pattern of change of rendement (%) of glucose syrups at saccharification levels at various enzymatic concentrations

Based on the t-test on the two treatments of saccharification time of 72 hours and 84 hours, it turn out that the rate of the rendement showed a significant difference. At the 84 hours saccharification time, liquefied glucose tended to decrease, because of the activity of the enzyme had decreased, or the existence of resistance of the higher sacccharide than the formation of the glucose. The higher is the concentration, the higher was the rendement of amyloglucocidase. This was caused by the break of the glucose molecule from the chain of the long polymer as the result of hydrolysis by the alpha-amylase, which would be quicker on the higher concentration of amyloglucocidase. With the higher concentration of the enzymatic glucocidase, the contact between the enzyme and the substrate was multiplied, so that the formation of complex enzyme and substrate and the quantum of the catalysis reaction become higher. As the result of the formation of aligosaccharide, the weight of the molecule lowered down and the glucose from the higher polymer was much higher (Pazur, 1965).

The comparison between the rendement and the liquefied glucose acquirement from the arrowroot starch and the tapioca, was derived from the fact that the arrowroot has a higher rendement as compared to tapioca. This was predicted on account of the fact that arrowroot has higher amylase with a tie of α(1-4) glycoside and α(1-6) glycoside. The alpha-amylase enzyme would hydrolyze the tie α(1-4) glycoside on the polysaccharide with a random degradation in the central part or inside of the molecule. Whereas the amyloglucocidase would hydrolyze α(1-4) glycoside and α(1-6) glycoside whose activity was slower as compared to the alpha-amylase (Fogarty, 1983). Based on that case above, the height of the amylase content in the arrowroot would cause the break of the tie of the hydrogen to be easier and faster. It was predicted that because that the tapioca starch the amylopectine content was higher, at the same time it was probable that the polysaccharide with the tie of α(1-4) had not been fully degraded yet. The result of the rendement was 85.31% of liquefied glucose from the arrowroot and that of tapioca was 78.73%. The data mentioned were derived from 3 observation.

The observation result on the liquefied glucose of the arrowroot starch by using HPLC showed that the fructose content was 4.70%, glucose 11.72%, and maltose 2.84%, whereas that of tapioca had fructose content of 8.70%, glucose 11.90% and maltose 9.50%.

Based on this fact, the optimum condition of the saccharification should be done on the substrate concentration of 30% at the 72 hours time with the enzymatic concentration of 53,913.42 U/kg substrate.

The result on the economic account of liquefied glucose of the arrowroot, when fully developed already, the price of liquefied glucose of the arrowroot may equalize the liquefied glucose of the tapioca. In October 1998, the price of the tapioca was around RP. 1.700/kg, whereas that of the arrowroot was Rp. 2.500,- because of its scarcity, not yet spread out in the society. However, if the government program is successful, so that arrowroot plant would be abundantly found everywhere, the arrowroot plants could have been reduced and could compete with tapioca. Production cost per hectare of the arrowroot plants would be around Rp. 3.000.000,- (1 ha can produce 20 tons of arrowroot slabs, with the starch rendement of 15%).

Conclusion and Suggestion

A. Conclusion

Based on the result of the chemical analyses and economical survey, this research can be concluded that the arrowroot starch can be used as an alternative source of the raw material for liquefied glucose. The enzymatic hydrolysis process of the arrowroot to become liquefied glucose is influenced by the substrate concentration, by enzymatic α-amylase concentration, and by amyloglucocidase concentration as well as by the time required for saccharification. The result of the optimum liquefied glucose was acquired at the substrate concentration of 30%, α-amylase 53,913.42 U/kg substrate and amyloglucocidase 60,319.28 U/kg substrate. On those conditions, the time required for saccharification was 72 hours. The rendement acquired was 85.31% and DE 86.09.

B. Suggestion

1. Further experiment on more efficient time for liquefaction process is still needed in order to reduce energy for liquefaction.
2. Further experiment is needed to get a scale-up of the process of the arrowroot starch liquefaction from the laboratory scale to factory scale.
3. The requirement of the arrowroot as the raw material for liquefied glucose would be that the input fulfills the requirement in term of quantity, quality, continuity, and the competing price of the raw material for the carbohydrates. For that purpose, technical training for the arrowroot farmers will be necessary carried out by the involved instances.

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