Enzyme Production from Cassava Peels by *Aspergillus Awamori* Kt-11: The Making of Natural Sweetener from Several tubbers

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Abstract

The use of cassava (*Manihot esculenta* Crantz) peel for enzyme production has not been widely used. The purpose of this study was to produce complex amylase enzymes from cassava peel by *A. awamori* KT-11 and apply them in the manufacture of natural sweeteners. Enzyme production is carried out on red and white cassava peel. Media of cassava peel sterilized, inoculated with 1% *A. awamori* KT-11, incubated for 5 days, then dried at 50°C and mashed. Making sugar is done on cassava flour, sweet potato (*Ipomoea batatas* L), taro (*Colocasia esculenta*) and cocoyam (*Xanthosoma sagittifolium*) with different concentrations of 10%, 15%, 20%, and 15% and 20% enzyme concentrations. The hydrolysis process is carried out for 3 days at 60°C. The enzyme activity in red cassava peel was 405,006 U/mL and white cassava peel was 321,239 U/ml. The sugar produced in cassava, taro, sweet potato, and Cocoyam was 101.38 mg/mL, 81.18 mg/mL, 55.929 mg/mL, and 42.874 mg/mL, respectively. The results of TLC showed that cassava and taro sugar contain maltose, lactose and glucose, sweet potatoes contained glucose and dextrin and Cocoyam containing fructose. The sweetness level of sugar from cassava, taro, sweet potato and Cocoyam is 14 brix, 12 brix, 9 brix and 9 brix, respectively.

Keywords: *Aspergillus awamori* KT-11, amylase, tuber, sugar

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Introduction

Indonesia is one of the tropical countries rich in resources microorganism, some of which can be used for the production of enzymes, such as *Aspergillus sp., Rhizopus sp. and Trichoderma reesei,* (Perwitasari *et al.*, 2017). Group of mold *Aspergillus sp*. was the most dominant group in producing amylase enzymes for the hydrolysis of starch. Biotechnology Research Center has a collection of *A. awamori* KT-11 which have the potential lipolytic and that it has been used in several studies. The use of the enzyme amylase more interest because of the environmentally friendly solution which happens to be more specific and did not result in a distorted sense of the final product (Nangin & Sutrisno, 2015). Enzymatic hydrolysis is essential for producing a monosaccharide or disaccharides from starch. The results of the hydrolysis of starch into sugars was later used as a natural sweetener alternative.

Indonesia is also one of an agricultural country with natural resources are very abundant. The abundant natural resources of this, yet many under utilized. Some of its commodity raw material is thus a superior product in another country, so according to Safitri (2014) exported more raw materials to other countries with a relatively low price. One of the commodities that have not been put to good use, namely tubers (Husna *et al*., 2013). The developed countries have long been utilizing food as processed products of high nutritional value and the economic has a large market opportunity.

The high content of carbohydrates in tubers makes one a very biological resource potential to be developed mainly in an effort to realize the national food resilience (Ambarsari *et al*., 2009). Types of tubers are very diverse, including cassava, sweet potato, taro, cocoyam, the tuber of potato tubers arrowroot, black and others In General, the sweetness of the tubers is obtained through a process of breaking down carbohydrates (starch) by the

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enzyme amylase into sugars. Sugar produced from the decomposition of glucose, sucrose, and fructose. This type of sugar is what determines the sweetness of each type of tuber. Sweetness on the tuber is correlated with the amount of sugar, especially reducing sugar such as glucose and fructose (Alkayyis & Susanti, 2016).

Sugar is an important commodity for the people of Indonesia, especially for consumption and food processing. According to the Ministry of agriculture (2017), national sugar consumption in the years 2013 and 2014 were amounting to 5.6 million tonnes the year 2015 and 2016 were amounted to 5.8 million tonnes, while the year 2017 was amounting to 5.7 million tonnes. The current domestic sugar production is estimated to reach only 2.2 tons, while consumption is about 5.7 million tons for the year 2017, so additional required about 2.5-3 million tons of sugar imports per year (Ministry of Agriculture, 2017). This encourages the emergence of a variety of efforts to increase the production of natural sugars.One alternative that has been taken, namely the attempt to produce sugar from tubers by means of hydrolysis starch into sugar

Raw material for producing glucose is material containing polysaccharide, obtained from starch. Starch is a polymer with the chemical formula anhydrous monosaccharide ($C_6H_{10}O_5$), and with the main constituent amylosa and amylopectin (Johnson & Padmaja, 2013). Glucose and fructose production can use tubers containing starch, such as cassava, sweet potatoes, taro, cocoyam and so on.

Starch hydrolysis was done in two ways, namely by using acid or enzymes of starch solvers. Enzymatic hydrolysis method preferred because the resulting product better is also safer to consume than acid hydrolysis.

Several studies on liquid sugar from tubers have been carried out, including the manufacture of liquid sugar from cassava (Permatasari, and Yulistiani. 2015., Sutamihardja *et al*., 2015., Madara *et al.*, 2017), sugar from sweet potato flour (Robi'a & Sutrisno, 2015., Mesah *et al*. 2016., Mahmudatussa'adah,2014., Wei *et al*. 2017), liquid sugar from cocoyam (Rejeki *et al*, 2017), liquid sugar from taro tuber starch (Putra *et al*., 2015., Wahidah, 2017). The research was conducted to obtain information and solutions in tackling food needs.

This study was conducted to produce the enzyme glucoamylase and a natural sweetener from cassava starch (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), Cocoyam (*Xanthosoma sagittifolium*) and taro (*Colocasia esculenta*) and knowing the types of sugar contained in it, the research was done.

Materials and Methods

Microorganism

In this study using *A. awamori* KT-11 mold. This mold is a collection of Biotechnology Research Center that have the potential to be amylolotic. *A. awamori* KT-11 was cultured on PDA media and incubated for 5 days at room temperature.

Preparation of materials and media production

The processing of flour bulbs beginning with how fresh tubers, peeled and washed, then cut into thin and then put in the oven at a temperature of 50ºC during ± 2 days. Dry tubers that are already mashed, filtered with filter 150 µm so obtained bulbs flour.

Preparation of enzyme production media, performed by means of the cassava peel (the inside) cleaned then cut small. As many as 500 g cassava peel are put into a baking dish and add 10% water containing minerals (K_2HPO_4 1%, KH_2PO_4 1% and Ammonium Sulfate 2.5%), then sterilized at 121ºC for approximately 15 minutes.

The production of the enzyme powder glukoamilase

The production of the enzyme glucoamylase is done by culturing of 5 ml suspense mold *A. awamori* KT-11 inoculated to the media cassava peel medium, stirred, covered paper and incubated for 5 days at room temperature. After that in dry in the oven at a temperature of 50ºC, crushed with a blender, strained and retrieved the powder enzyme glucoamylase.

Extraction of glucoamylase enzyme

The extraction of complex amylase enzymes was carried out by means of 10 g of enzyme powder added 50 mL of citrate-phosphate buffer pH 4.8, then shaken with a

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magnetic stirer in the refrigeration chamber for ± 2 hours. Centrifuged at 10000 rpm at 4ºC for 10 minutes. The filtrate obtained as an enzyme (crude enzyme) is ready for use.

The assay of glukoamilase enzyme activity

A total of 0.02 grams of starch was weighed, then 0.4 mL of citrate-phosphate buffer pH 4.8 was added, then heated at 60ºC until it became clear. The solution that has been clear is then put into thermolyne at 60ºC. A total of 0.1 enzyme solutions were put into the test tube, then incubated in thermolyne for 60 minutes, then heated in boiling water for about ± 1 minute to stop the enzyme activity, then cool. Cold solution is added with 0.5 mL distilled water until the solution volume becomes 1 mL. Substrate control was made without enzymes, while control of enzymes was made without starch substrates. Blanks are made without enzymes and substrates. The sample was tested according to the Somogi-Nelson method, 1941). One unit of enzyme activity is equivalent to 1 mg of reducing sugar per mL formed under the above conditions.

The measurement of protein enzyme glukoamilase (Phillip Hanson, 1981).

The enzyme solution was measured using a spectrophotometer at a wavelength of 280 nm.

The hydrolysis of starch into sugars

Tuber flour is weighed 0.5 g (10%), 0.75 (15%) g and 1 g (20%), then put in a test tube, then 5 mL of distilled water is added, then shaken with vortex and gelatinized. The sample was put in a waterbath at 60ºC, then added the enzyme 0.5 mL (10%) and 0.75 mL (15%). Incubation time is carried out for 24, 48 and 72 hours. Control is made with the same treatment, but without the addition of enzymes. The incubated samples were then heated for 2 minutes to stop the enzyme activity, then centrifuged at a speed of 7000 rpm at 4ºC for 10 minutes. The filtrate was taken and put into a tube and ready to be tested for reducing sugar using the same procedure as when measuring the standard D-glucose solution.

The same procedure was carried out for larger scale sugar production (200 mL) with the best composition from the research results (20% enzyme concentration, 20% starch concentration and 72 hours incubation time). The temperature used was 60ºC and room temperature. Sugar concentration is done by heating at a temperature of 100ºC (5 times concentration)

Measurement of levels of sweetness of sugar

Sugar production samples were tested for sweetness using a refractometer

Analysis of types of sugar in KLT

Eluent n-butanol, glacial acetic acid, water prepared with a ratio of 2: 1: 1, then put into the chamber. TLC plates are cut in size 10x10 cm with a start and finish distance of 1 cm each. The standard D-glucose, D-fructose, maltose, dextrin and lactose solutions were made 1000 ppm, then each sample and standard were dropped on the plate by 2 µL. Then the plate is inserted into the chamber and eluted until it reaches the finish line. The plate is dried with a hairdryer then sprayed with DPA solution 2 times, then dried in an oven 120ºC for 10 minutes and the spot formed is observed.

Results

Enzyme activity

The enzyme activity obtained on each of them were 404,989 U / ml (red cassava peel) and 321,239 U / ml (white cassava peel). Protein levels were obtained 62.8 mg/ml (red cassava peel) and 60.54 mg/ml (white cassava peel) while reducing sugars were 10.719 mg/ml and 9.156 mg/ml respectively (Table 1).

Table 1. The results of the measurement of enzyme activity, reducing sugar and protein from media of Cassava white peel and Cassava red peel

Substrate	Enzyme activity (U/mL)	Reducing sugar (mg/mL)	Protein (mg/mL)
Cassava white peel	321.239	9.156	60.54
Cassava red peel	404.989	10.719	62.8

Hydrolysis of starch into sugar

Reducing sugar obtained at starch concentrations of 10%, 15% and 20% with 10% enzyme concentration for 72 hours incubation period, respectively are 62.26 mg / ml, 68.72 mg / ml and 72.53 mg / ml, while at 15% enzyme concentration obtained 63.83 mg / ml, 82.67 mg / ml and 84.61 mg / ml

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respectively. The optimal conditions for hydrolysis of cassava starch are 20% starch concentration, 15% enzyme concentration and 72 hours incubation time.

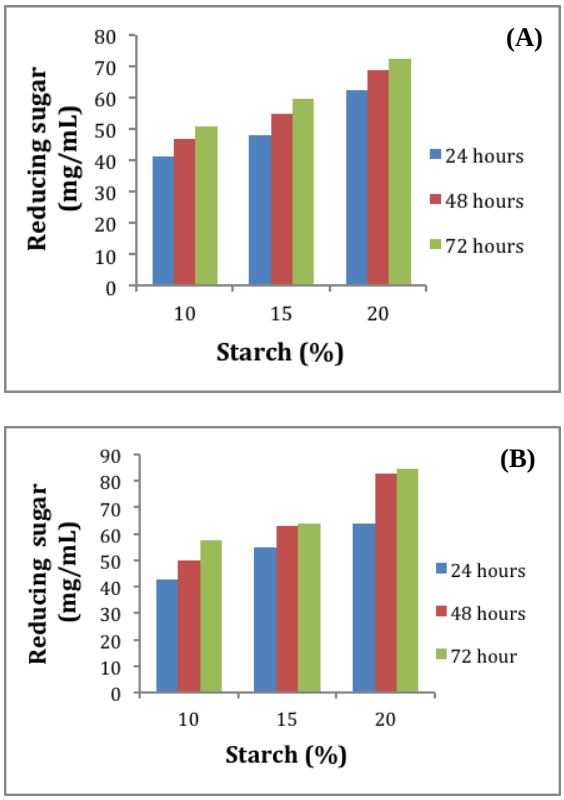


Figure 1. The results of the reducing sugar starch cassava by using enzyme concentration of 10% (A) and 15% (B).

The results of sweet potato starch hydrolysis (Figure 2), showed that the sugar, which obtained at 10%, 15%, 20% starch concentrations for 72 hours of incubation period, each is 34.87 mg / ml, 49.85 mg / ml and 51.55 mg / ml (10% enzyme concentration) and 38.62 mg / ml, 51.50 mg / ml and 52.49 mg / ml (15% enzyme concentration).

The results of the analysis of reducing sugars from Taro tubers which are based on starch concentrations of 10%, 15% and 20% respectively are 35.38 mg / ml, 40.10 mg / ml and 55.87 mg / ml (10% enzyme) and 45.49 mg / ml, 51.14 mg / ml and 61.39 mg / ml (15% enzyme). The optimum conditions for hydrolysis of taro tubers were 15% enzyme concentration, 20% starch concentration and 72 hours incubation time.

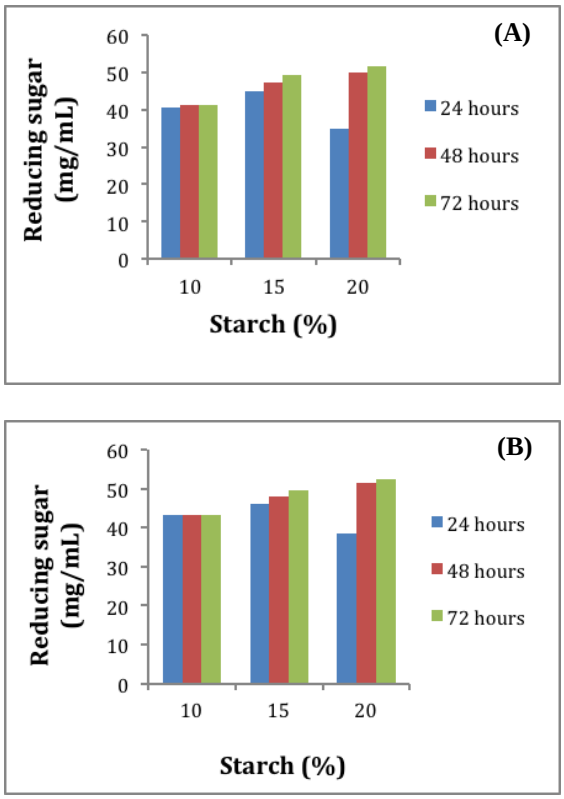


Figure 2. The results of the reducing sugar sweet potato starch using enzyme concentration of 10% (A) and 15% (B)

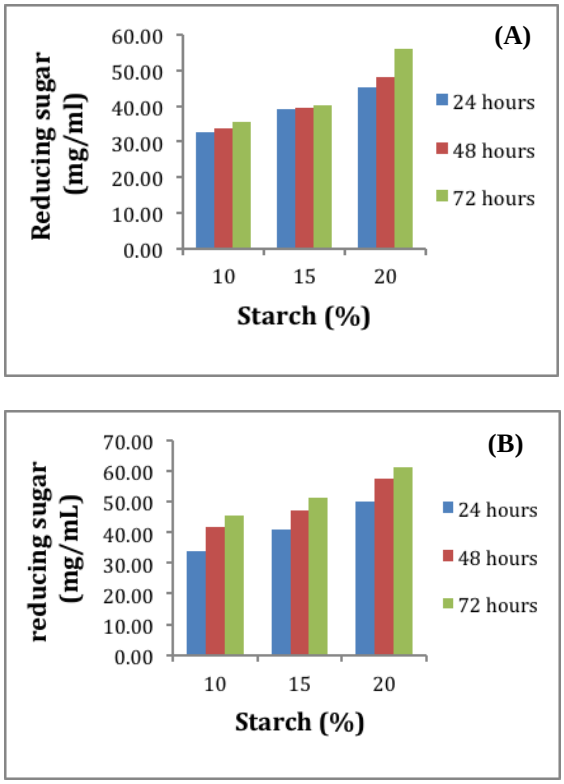


Figure 3. The results of the reducing sugar starch taro with enzyme concentration using 10% (A) and 15% (B).

The hydrolysis pattern of starch flour into sugar (Figure 4), just like the pattern in sweet potato and cassava starch, only the sugar content produced is smaller. At 20% starch concentration with 10% enzyme concentration, producing sugar as much as 27.13 mg / ml, 27.64 mg / ml and 29.65 mg / ml while at 20% starch concentration and 15% enzyme concentration obtained results of 30.05 mg / ml, 32.95 mg / ml and 42.87 mg / ml during a 72 hours incubation period.

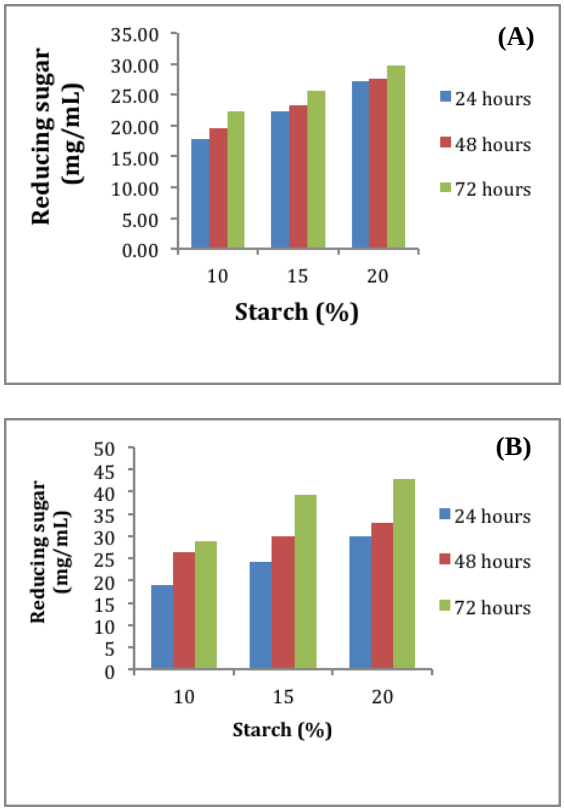
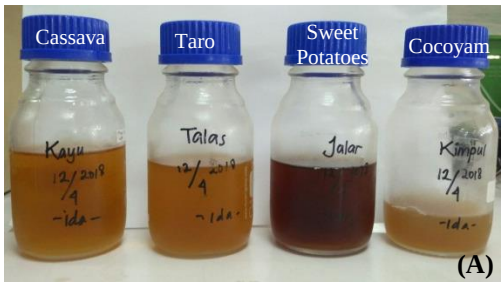


Figure 4. The results of the reducing sugars starch Cocoyam by using of enzyme concentration of 10% (A) and 15% (B).

The best results sugar obtained from the four tubers were substrate concentration of 20%, enzyme concentration of15% and 72 hours incubation time at 60ºC temperature. Furthermore, liquid sugar is produced on a larger scale (200 mL) at 60ºC and also at room temperature (30ºC), to get the best temperature conditions in producing liquid sugar. The sugar produced at 60ºC gives better results than at 30ºC. The liquid sugar was concentrated to 10 times at 100ºC. Sugar production at 60º C can be seen in Figure 5



Reducing sugar produced from the four types of tubers (cassava, taro, sweet potatoes and Cocoyam) at optimum temperature were 101,380 mg / mL , 81,180 mg / mL, 55,929 mg / mL, 47,874 mg / mL, respectively. Meanwhile, hydrolysis carried out at room temperature results in lower reducing sugar levels than those carried out at 60ºC, except for taro tubers.

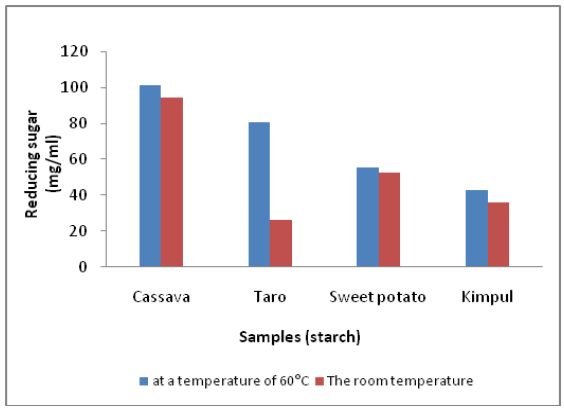


Figure 6. Reducing sugar levels from four different tubers on optimum condition (concentration of starch 20% and concentration of enzyme 20%) incubation at a temperature of 60° C and the room temperature for 72 hours.

The results of measuring the sweetness of sugar showed in Table 2. The degree of sweetness is shown in brix units. Brix is the amount of dissolved solids (g) every 100g of solution. The results of the analysis show that sugar produced from cassava has the highest degree of sweetness, while the tuber Cocoyam has the lowest yield.

The type of sugar produced by hydrolysis of tuber samples was analysed qualitatively using TLC method. The mobile phase used is a mixture of n-butanol: acetic acid: water with a ratio of 2: 1: 1. The eluent is semi-polar with a polarity index of 5.8. The use of this eluent is because most monosaccharides or disaccharides are polar, so the sugar content in the sample will migrate and separate well.

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Qualitative testing of TLC sugar involves standard sugars (glucose, fructose, maltose, lactose, and dextrin) were using during analysis.

Table 2. Results of sugar sweetness measurement

Samples	The level of sweetness before concentred (Brix)	Sweetness after 5x concentred (Brix)
Cassava	14	80
Taro tuber	12	70
Sweet pota	9	60
Cocoyam	9	40

This qualitative test is carried out by comparing the value of Rf produced by the spot in the sample and the standard. If the Rf value of the sample produced is the same as the standard Rf value, it indicates the content of the compound in the sample is the same with standard.

Table 3. Rf value standards and samples

Samples	Code	The amount of stain	Rf	Estimates A compound
Glucose-standard	G	1	0.65	-
Fructose-standard	F	1	0.66	-
Maltose-standard	M	1	0.48	-
Lactose-standard	L	1	0.56	-
Dextrin-standard	D	1	0.58	-
Cassava	Ka	1	0.48	Maltose
		2	0.56	Lactose
		3	0.64	Glucose
		4	0.68	-
Taro	Ta	1	0.48	Maltose
		2	0.56	Lactose
		3	0.65	Glucose
		4	0.68	-
Sweet Potato	Ja	1	0.51	-
		2	0.58	Dextrin
		3	0.65	Glucose
		4	0.68	-
Cocoyam	Ki	1	0.66	fructose

The results of TLC on fermented sugar samples from 4 tuber types are shown in Table 3. (Figure 7). Sugar cassava and taro sweet potato samples showed that there were 4 spots of sugar formed. Of the four spots, it is thought to contain maltose, lactose and glucose while one other spot is outside of the standard Rf value. Sweet potatoes also have 4 spots, with Rf values that are close to the standard dextrin and glucose, while the other two spots may be other types of sugar outside of standard sugars. Kimpul tuber only has 1 yellow spot known as fructose.

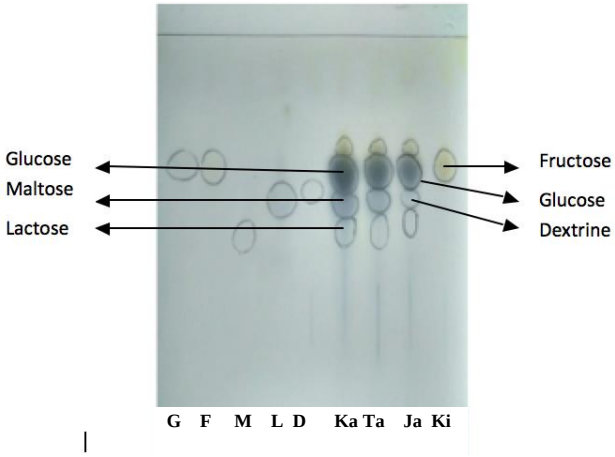

Figure 7. The result of qualitative analysis of sugars from starch hydrolysis of Manihot esculenta (Ka), Colocasia esculenta(Ta), Ipomoea batatas (Ja), Xanthosoma sagittifolium (Ki), Glucose (G), Fructose(F), Maltose(M), Lactose(L), Dextrine (D) in TLC.

Discussion

Making amylase enzymes complex from red and white cassava peel give different results, this is because the carbohydrate content in cassava peel is different as well as the mineral elements it contains. Observed from the media, the red cassava peel after sterilization appears to have white granules which are likely the starch which come out from the cassava peel and the peel structure itself is somewhat soft appearance, while white cassava peel seems to be driedThe humidity is one of the factors that support the growth of molds in the media to become more fertile. Compared to white cassava peel, media added with red cassava peel is slightly moist that could be one possibility of the different result in enzyme activity. The enzyme activity obtained on each of them was 404,989 U / ml (red cassava peel and 321,239 U / ml (white

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cassava peel). This result is consistent with a resultreported by Pe rwitasari et al. (2017) stated that the enzyme produced by Aspergillus awamori KT-11 using cassava peel substrate produces enzyme activity around at 300-400 U/mL.

Red cassava peel media gives higher enzyme activity results than white cassava peel. This is possible because the starch and mineral content of red cassava peel is higher compared to white cassava peel. The results of this study provide an information that cassava peel contains a lot of carbohydrates so that cassava peels can be used as a medium for producing the enzymes. This is reinforced by Grace (1977) stated that the carbohydrate content of cassava peels is about 50% of the carbohydrate content of the tuber parts, as well as Richana (2013) reported that starch content in cassava peel was between 44-59%.The application of enzymes to tuber flour media usisng enzyme extracts which is obtained from the medium of red cassava skin because of the enzyme activities of this biomaterial is higher (404.989 Unit).

In this study, 4 types of tubers starch were used namely cassava, sweet potato, taro, and cocoyam flour. As already known, starch will be broken down into sugar due to the action of glucoamylase or amylase.. The hydrolysis process is carried out for 72 hours at 60° C. The results of reducing sugar levels for cassava samples (Figure 1) obtained a linear relationship between substrate concentration, enzyme concentration, incubation time, and reducing sugar content. The higher the substrate concentration, the higher the reducing sugar content can be produced as a result of the more starch can be hydrolyzed. The greater the percentage of complex amylase enzymes added, the greater the reducing sugar content produced as a result of enzymatical digestion of starch at glycosidic bonds, hence increase its products.The longer the hydrolysis time of starch, the more the sugar level reduces. Longer contact time between enzymes and starch let enzymes to digest its substrate in their optimal activity.

Hydrolysis of sweet potato starch showed that increasing the starch concentration, enzyme concentration, and incubation time, can enhance the yield of sugar (Figure 2). Except for 15% and 20% starch concentrations, both enzymes were added 10% and 15% (incubation time 24 hours). This is because the gelatinization process, sweet potato at a concentration of 20% has the highest viscosity among the other tubers. This viscosity is influenced by the amylose content in the starch. According to Putri and Nisa (2015), sweet potatoes have greater amylose content among other tubers, which is around at 25%. The higher the content of amylose in starch, the thicker the gelatinization starch is, the more difficult the enzyme to hydrolyze the starch. In addition, low sugar levels can be caused due to less optimal stirring, so that the enzyme is not perfect to carry out the hydrolysis process of the starch.

The reducing sugar content produced from hydrolysis of taro tuber starch (Figure 3) is also directly proportional to the concentration of enzyme, substrate concentration and incubation time. The more enzyme concentration, substrate concentration, and the longer the incubation, the higher the sugar content can be obtained. This result shows that the higher the concentration of the enzyme, the more substrate that can be hydrolyzed so that the simple sugars as the final product also increase. The longer the incubation is carried out, the more substrates that can be hydrolyzed by enzymes and produce the reducing sugars. The optimum conditions for hydrolysis of taro tubers were 15% enzyme concentration, 20% starch concentration and 72 hours incubation time. The reducing sugar content obtained is 61,389 mg / mL. Reducing sugar produced by ta starch as is lower than cassava starch. This is likely due to the different in the starch content. According to the reports, cassava starch content is 80% (El-Sharkawy 2012) and taro is between 70-80% (Kaushal *et al*., 2015).

The hydrolysis pattern of starch flour into sugar (Figure 4), same as the pattern in sweet potato and cassava starch, only the sugar content produced is smaller at 20% starch concentration with 10% enzyme concentration, producing sugar as much as 27.13 mg / ml, 27.64 mg / ml and 29.65 mg / ml while at 20% starch concentration and 15% enzyme concentration obtained results of 30.05 mg / ml, 32.95 mg / ml and 42.87 mg / ml. The gelatinization process of Cocoyam starch is rather difficult because it is thick so the possibility of starch hydrolysis process by enzymes does not decompose completely. According to Falade & Okafor (2013) report that starch contained in the capsule is 75.5% carbohydrates, actually the starch content is

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quite high but because of the possibility of high amylose content that the gelatinization process of Cocoyam starch becomes difficult and the hydrolysis process becomes less perfect. Starch hydrolysis in all four tuber samples showed that the enzyme reaction that occurred still had not reached equilibrium. This is indicated by the still increasing levels of reducing sugars to the optimum state, so there is still a possibility that the reducing sugar levels will continue to rise if the enzyme concentration and incubation time are increased to reach a balanced state.

The results of the hydrolysis of the four samples have different colors. The color of the sugar produced is yellow to brownish yellow. The yellow color formed can be produced by the content of beta-carotene in the tuber sample. According to Islam *et al*., (2015), sweet potatoes have the highest content of beta-carotene among other tuber samples, so the yellow color produced is more concentrated. According to Triyono (2008), the yellow color can also be caused by the caramelization process. Caramelization is a reaction of changes that occur in compounds such as reducing sugar when heated at high temperatures to produce a brownish yellow color. The color produced has met SNI quality requirements 01-2978-1992 regarding glucose syrup which is colorless to yellow, except for the results of hydrolysis of sweet potatoes where the color produced is still too brown.

Analysis of reducing sugars on a large scale (Figure 6) yields higher values than hydrolysis using a tube. This is because the container used is larger (Erlenmeyer) which has a larger surface area so that the enzyme will be more easily spread evenly throughout all parts of the flour. In addition, the enzyme used has higher activity (404,983 U / mL), while the enzyme used before is only 321,233 U / mL, so the hydrolysis results will be much better. Meanwhile, hydrolysis carried out at room temperature results in lower reducing sugar levels than those carried out at 60^{o}C, but not much different, except for taro tubers. This is because the amylase enzyme can work optimally at 60ºC so that the hydrolysis process at room temperature does not work optimally.

The degree of sweetness is shown in brix units. Brix is the number of dissolved solids (g) every 100g of solution. The results of the analysis show that cassava has the highest degree of sweetness, while the tuber has the lowest yield. This is because cassava has the highest starch content of around 83% (Mustafa 2015), while the amylose in the tuberous tuber starch is 35.34%, two times greater than amylose of cassava (Warkoyo *et al*. 2014). The higher the starch content in the tuber, the more reducing sugar produced from hydrolysis, so that the degree of sweetness is also higher. The sweetness level of the sugar that is concentrated is greater than that of unconcentrated samples. This result shows that the concentration process can increase the degree of sweetness of the sugar

Qualitative testing of sugar using TLC involves standard sugars, especially reducing sugars, namely glucose, fructose, maltose, lactose, and dextrin. According to Ristyoningsih (2011), starch hydrolysis by the α-amylase enzyme will produce glucose and maltose, while β-amylase produces maltose and dextrin, while glucoamylase produces glucose so that the standard solution used is sufficient to represent the type of sugar hydrolyzed by the enzyme used (Figure 7).

The results of TLC obtained were in accordance with reducing the sugar content of each sample of the tuber. Cassava has the highest starch content and reducing sugar levels. This is indicated by the results of TLC obtained by having the most higher sugar compounds compared to other tubers. In addition, the spot color produced is estimated to be the most concentrated glucose compound among the others. This shows high glucose levels in the sample. It is different from the Cocoyam tuber, where the tuber has the smallest starch content and reducing sugar content which is characterized by the results of TLC which is only one spot and is thought to be a fructose compound.

Conclusion

Cassava peel can be used for the production of complex amylase enzymes with high enzyme activity. Sugar can be produced optimally from tubers, with 20% substrate concentration, 15% enzyme concentration and 72 hours incubation time. The reducing sugar content produced from the highest to the lowest is cassava, taro sweet potato, sweet potato, sweet potato tuber. The results of TLC show that cassava and taro tuber contain

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maltose, lactose, and glucose, sweet potatoes contains glucose and dextrin and Cocoyam tubers contain fructose.

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