NYPA PALM SAP AS FEEDSTOCK FOR FERMENTED ALCOHOL PRODUCTION

by

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ABSTRACT

Nypa palm is the among the few palms that grow well in mangroves. The tapping from fruit of nypa palm that produces the sap is a good substance for alcohol fermentation due to its high sugar and low ash contents.

The implementation of alcohol fermentation by nypa palm sap was conducted in laboratory scale. The result shows that the sap of nypa palm is a good feedstock for fermented alcohol. The best yield is obtained by fermentation of feedstock containing 25% starter, 4% NPK solution, and 5% bread yeast. The yield of alcohol concentration is about 11% (88% alcohol content) of feedstock.

Key words : *Nypa-alcohol.*

I. INTRODUCTION

Nypa palm (*Nypa fruticans* Wurmb) grows in brackish coastal waters (areas in which salt and fresh water mingle), and can grow over vast areas in Papua New Guinea, Malaysia, Indonesia, the Philippines, Bangladesh, India and has invaded the Niger Delta in Africa. It has many traditional uses, including the brewing of local alchohol (toddy), sugar, rope-making and thatching (hence the palm's local name 'Attap Chee', from it's use in roofing the traditional 'Attap house'). In 1922, Cole informed that nypa palm sap was the cheapest source of alcohol in the world namely 0.027 dollars per liter of 90% alcohol.[2, 8, and 11]

Nypa fruticans Wurmb belongs to family Arecaceae. The stem, flower, and fruit of this nypa palm are shown in Figure 1 and Figure 2. Nypa palms produce large quantities of a sugar-rich sap that can be used for ethanol production. Nypa palm has been reported to have ethanol yields ranging from 6480 to 20,000 liters/ha, which makes it several times more productive then the sugarcane. The palm can be tapped 4 years after planting, and will yield for 50 or more years (by comparison, the oil palm has a maximum life of 15 years). Traditional methods of harvesting are intriguing, and include slapping and kicking the tree on a daily basis to encourage the flow of sap.[1, 2, 3, and 9]

Figure 1
Underground stem of nypa palm

Figure 2
Flower and fruit of nypa palm

The sap as tapping products from the fruit of nypa palm has high sugar contents and very sweet taste with colorless liquid. Thus the nypa sap can be used as feedstock for alcohol fermentation. The sap is collected by cutting the fruit at its point of attachment to the stalk. During this tapping process, this fruit secrete the sap. It's almost colorless and has very sweet taste. From six different palm samples were analyzed in the Philippines, the best quality of the sap in grams per 100 cubic centimeters containing 18.00 total solids, 17.00 sucrose, 0.48 ashes, and trace of reducing sugars. The alcohol production from nypa palm sap should be above 6% of the sap. In favorable conditions it would be 7%. It is seen that 9,300 gallons of sap would produce about 650 gallons of alcohol, which would be the annual yield per acre.[4 and 7]

In Malaya, Dennett gives the real maximum yield per spathe as 0.1025 gallons. Base on of two spathes in tapping per palm, 200 palms per acre and 340 tapping days per annum, this gives a yield of 13,940 gallons of sap per acre per annum. He gives the mean alcohol content as 10 per cent by volume, so that the mean yield per acre per annum would be 1,394 gallons. He also gives the real minimum mean yield as 1,270 gallons. In "*An Outline of Malayan agriculture*", Grist gives the theoretical yield of absolute alcohol as over 1,100 gallons per acre per annum.[6 and 8]

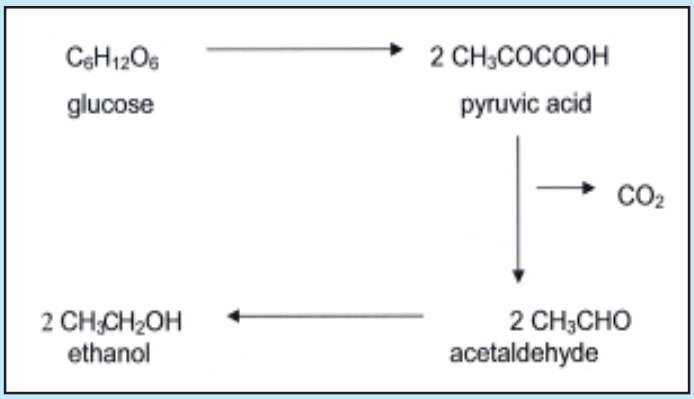

Figure 3
Reaction sequences for the alcohol fermentations [5]

Tabel 1
Treatment methods for alcohol fermentation process

Treatment method	Volume of sap (%)	Volume of starter (%)	NPK addition (%)	Microbes
P-1	90	10	0.2	*S. serevisiae*
P-2	90	10	0.4	*S. serevisiae*
P-3	86	14	0.4	*S. serevisiae*
P-4	90	10	0.4	*S. serevisiae* 5% bread yeast
P-5	75	25	0.4	*S. serevisiae*
P-6	75	25	0.4	*S. serevisiae* 5% bread yeast

Fermentation is one of several methods in alcohol production. In the process of alcohol fermentation, biochemical activities of microorganisms is usually used under anaerobic conditions.[5] During fermentation, feedstock changed to alcohol. Sucrose content of feedstock is broken down to glucose, and glucose fermentation produces alcohol.[10] Basically, fermented alcohol comes from glucose conversion. The yeast *Saccharomyces serevisiae* is usually used as supporting microbes for fermentation.

The alcohol fermentation is started with glycolysis process. The glucose compounds are broken down to pyruvic acid via Embden-Meyerhof pathways. The pyruvic acid is thenconverted to acetaldehyde and carbon dioxide by the microbes. Finally, this acetaldehyde was converted to ethanol (see Figure 3).

Indonesia is one of tropical countries has large of nypa palm forest, this palm has a very high sugar-rich sap yield that can be tapped continuously from the trees inflorescence. The nypa sap is a good substance for fermented ethanol production, however, the fermentation study with Indonesian nypa sap is limited. In connection with this conditions, an fermentation study was conducted with nypa palm from Sulawesi. This palm was used as feedstock for production of fermented alcohol. The objective of this study to support procurement of energy alternative.

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II. EXPERIMENTAL

A. *Material*

The alcohol fermentation was conducted in laboratory scale. The sap as feedstock was collected from a nipa palm forest in South of Sulawesi, by means of cutting the fruit at its point of attachment to the stalk.

B. *Microbes*

Saccharomyces cerevisiae and the bread yeast were used as microbial culture in this work. *S. cerevisiae* growing in the nypa sap was applied as starter for fermentation process. In order to support the microbial growth, the NPK solution was used as nutrition addition.

C. *Treatment Methods*

The process of alcohol fermentation was conducted in a bottle glass under anaerobic conditions and at room temperature. The substances of fermentation process consist of 500 ml nypa palm sap and starter. The solution of NPK and the bread yeast can be added when necessary.

The fermentation process was carried out in several treatment methods. The treatment was based on the fermentation substances used. The differences between the treatment methods are in the percentages of sap volume, starter volume and NPK addition. The treatment methods for the fermentation process are shown in Table 1.

The fermentation of *Nypa fruticant* sap was conducted batch system in room temperature during 24 hours incubation. Fermentation activities are monitored by some parameter such as microbial population, alcohol content, sugar content, Furthermore, the fermented sap is distillated at 70 ^{o}C to separate alcohol from water.

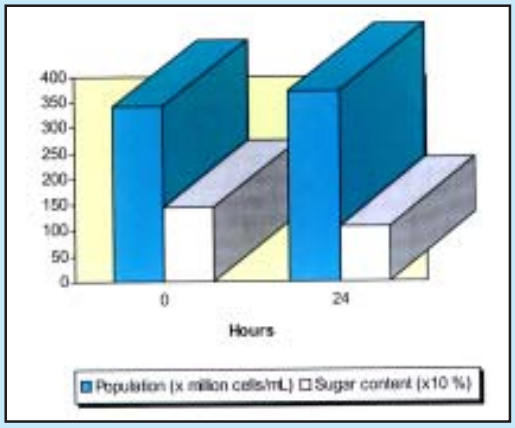

Figure 4
Yeast population and sugar content in P-1 during 24 hours

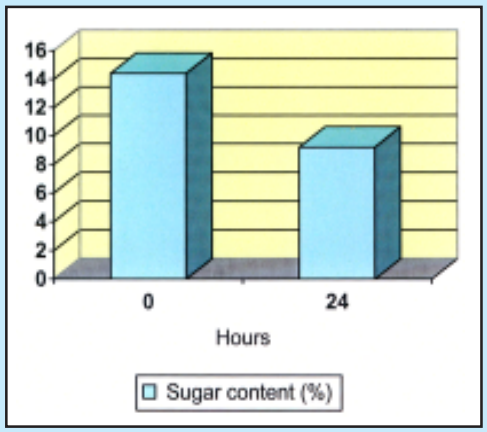

Figure 5
Sugar content reductions in P-2 during 24 hours fermentation

III. RESULT AND DISCUSSION

A. *Feedstock*

The tapping from fruit of nypa palm that produces the sap is a good substance for alcohol fermentation due to its high sugar and low ash contents. The sugar content of nypa palm sap is capable as feedstock for alcohol fermentation. The content of sugar is almost 60%. The total sugar is dominated by sucrose and glucose compounds. During process fermentation, the sugar was converted to

Table 2
The analysis data of nypa palm sap (before fermentation)

Analysis	Sample 1	Sample 2	Sample 3
Glucose (%)	26,25	26,30	26,19
Total sugar (%)	57,50	58,00	56,90
Sucrose (%)	29,12	30,12	29,17
Ash content (%)	0,53	0,55	0,42
pH	4,06	4,11	4,09

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alcohol compounds by microbial activities. The characteristic of the sap is acid with pH value is approx 4 (see Table 2).

B. *Alcohol Fermentation of Treatment*

The success of alcohol fermentation depends on the three important factors such as the quality of microbial cultures and feedstock as well as the condition of the biological process.

Saccharomyces cerevisiae was used as microbial culture on this work. *S. cerevisiae* that grew in the nypa sap was used as starter for fermentation process. P-1 contains nypa palm sap with 10% starter and 0.2% NPK. During fermentation process, the population of yeast is around 3 to 4 x 10^8 cells/ml (see Figure 4). The amount of the yeast cell is sufficient enough to support fermentation process of alcohol. Usually, minimum cell population of yeast for alcohol fermentation process is about million cells/ml.

The analysis result sugar content in nypa sap before fermentation process is around 14.4%. After 24 hours incubation, 25% of sugar content was reduced, therefore 10.8% of sugar content was still remain in the sap (see Figure 4).

When addition NPK solution as a nutrition was increased to 0.4% (P-2), the sugar reduction also increases. During 24 hours incubation, the sugar content reduction is approx 37.5%. The result of fermentation activity is shown in Figure 5.

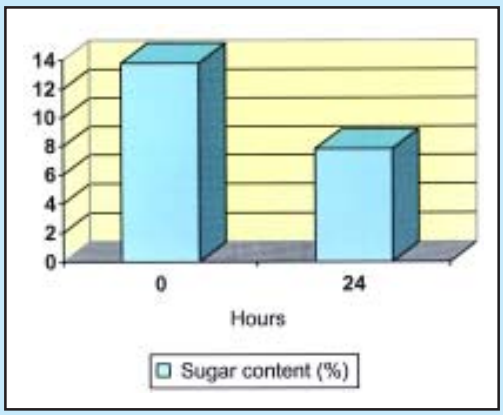

Figure 6
Sugar content reductions in P-3 during 24 hours fermentation

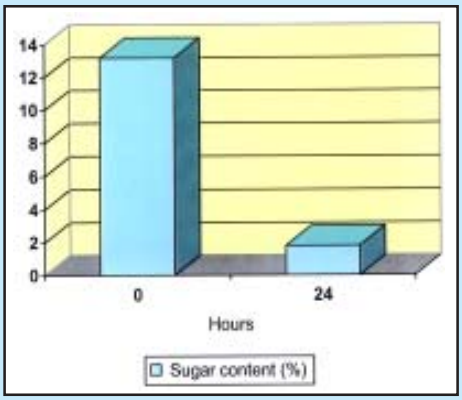

Figure 8
Reduction of sugar content in P-5 during 24 hours fermentation

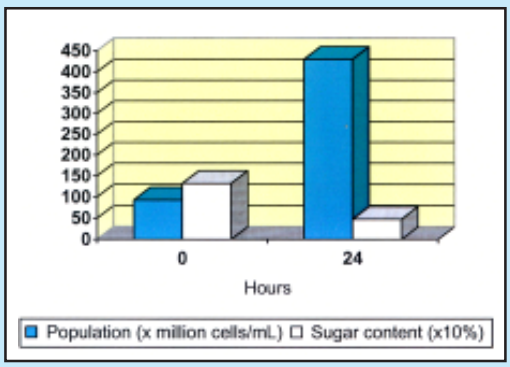

Figure 7
Yeast population and sugar content reduction in P-4 during 24 hours fermentation

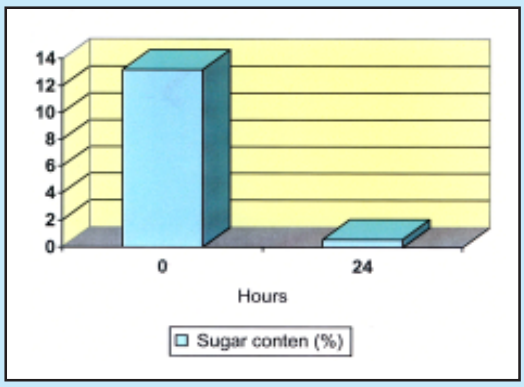

Figure 9
Reduction of sugar content in P-6 during 24 hours fermentation

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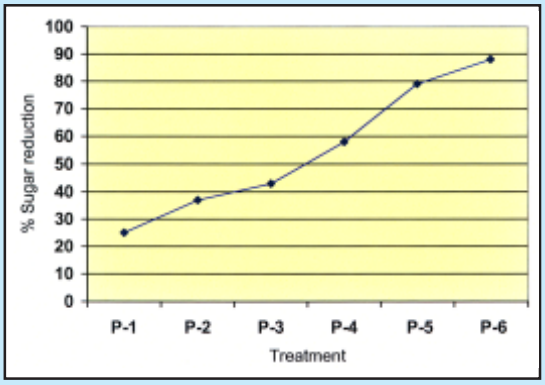

Figure 10
Curve of sugar content reduction during 24 hours fermentation in P-1 to P-6

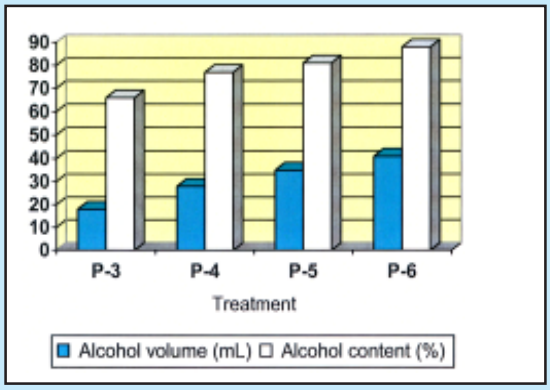

Figure 11
Alcohol content and volume of alcohol production in P-3 to P-6 during 24 hours fermentation

The treatment of P-3 is almost similar with P-2. The difference between them is on the starter addition. The starter for P-3 is increased to 14%. However after 24 hours of fermentation the reduction of sugar increases slightly. The reduction of sugar is 43% (see Figure 6).

P-4 is P-2 with 5% bread yeast addition. In P-4, the population of yeast increases significantly. During 24 hours fermentation, the population increase from 0.9 to 4 x 10^8 cells/ml. The capability of microbes to reduce sugar content is also improved. As a result during 24 hours incubation, the sugar reduction is approx 58% (see Figure 7).

In P-5 the starter addition was increased to 25%. The reduction of sugar is good by this treatment. The sugar reduction obtained is up to 79% during 24 hours incubation (see Figure 8).

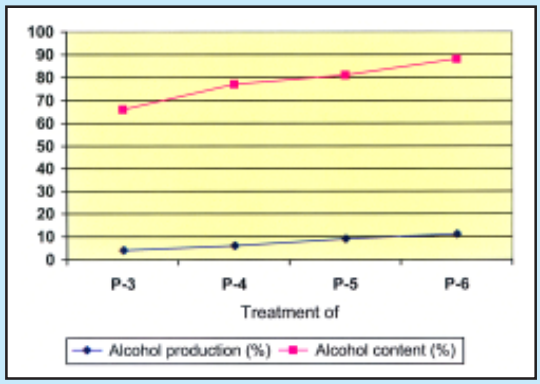

Figure 12
Percentage of alcohol production and alcohol content during 24 hours fermentation in P-3 to P-6

Table 3
Test result of the alcohol of fermentation product

Characteristics		Product-1	Product-2	Test Methods
- Ethanol	% (w/w)	85.24	86.05	GC
- Methanol	% (w/w)	0.07	0.07	GC
- n-Propanol	% (w/w)	0.05	0.05	GC
- Acetaldehyde	% (w/w)	0.03	0.03	GC
- Iso Amyl Alcohol	% (w/w)	0.1	0.1	GC
- Acidity as Acetic Acid	% (w/w)	0.07	0.07	ASTM D.1613
- SG at 15°C		0.8233	0.8233	Picnometer

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P-6 is P-5 with 5% bread yeast addition. In P-6, the fermentation process is apparently improve and after 24 hours incubation the sugar reduction increasing up to 87.5% (see Figure 9) Figure 10 shows the value of sugar reduction in nipa sap during fermentation process in P-1 to P-6. The yeast activities are capable to reduce sugar content in nipa sap from 25% to 88%.

During fermentation process in P- 3 to P-6, some of sugar content in the nipa palm sap converted to alcohol. The percentage of alcohol content and volume yield in P-3 to P-6 shown in Figure 11.

The lowest yields of alcohol come from P-3, which is around 18 ml with 66% alcohol content. The best yield of alcohol produced by P-6 is about 41 ml with 88% alcohol contents. This is equal with 11% of feedstock (see Figure 12).

The Specification of Alcohol

The best yield of fermentation from the nipa sap is fermented alcohol with 88% alcohol content. The content of alcohol is dominated by ethanol (more than 85%). The impurities also obtained in this product alcohol compounds such as methanol, n-propanol, and iso-amil alcohol are very low. Specification of fermented alcohol shown in Table 3. The specific gravity at 15^{o}C is about 0.8233.

IV. CONCLUSION

The sugar content in the sap of nypa palm is more than fifty per cent. Consequently the nypa palm sap is sufficient to be used as alcohol fermentation feedstock.

In alcohol production using nypa sap as the feedstock, the best yields was obtained when the fermentation was treated with 25% of starter, 4% NPK and 5% bread yeast. The yield of fermented alcohol is approx 11% (88% alcohol content) of feedstock.

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