Fermentation

by Endah Uad

Making Bioethanol from Leftover Rice by Fermentation Using Tapé Yeast

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Abstract. Leftover rice is rice that has been cooked, which is not desirable for human consumption but not stale. It is important to find out the ways to use this waste. One of them is making bioethanol, an alternative energy, because nowadays there are some energy crises. The purpose of this research was to determine the optimum process conditions in making bioethanol from leftover rice by fermentation using tapé yeast. Variables studied were age of cooked rice, fermentation time, and the weight ratio of yeast to the rice.

Cooked rice 200 grams which had 12 to 24 hours put into a plastic jar that was clean and dry. Tapé yeast 1 to 6 grams made into powder, put into the jar that already contained the rice, then mixed and closed, allowed the fermentation process occurred at room temperature. The process was run in 4 to 27 days. After fermentation had completed, all the materials were poured into the distillation flask and run at temperature of 78-82° C, for 2 to 3 hours.

The results showed that the fermentation product was relatively small quantity. Fermentation in making bioethanol needed 8 to 27 days, age of cooked rice maximum 24 hours, and the weight ratio of yeast to rice was 0.0067.

Key words: *bioethanol*, *rice*, *fermentation*, *yeast*.

1 Introduction

The scarcity of fuel oil has been going on a very broad impact on many sectors of life, especially for households that had been using kerosene fuel. Leftover rice is rice after cooking which is not desirable for human consumption but not stale, usually has 12 hours or more after cooking. In the Java community, if there are many celebrations, often a lot of rice is wasted. Restaurants or food stalls sometimes leaving rice every day because not all be consumed. One use of leftover rice is by being converted into bioethanol, which can be an alternative fuel in the household, thus reducing dependence on fossil fuels. The objective of this research was to determine the optimum process conditions in making bioethanol from leftover rice that fermented using yeast. The variables studied were age of cooked rice, fermentation time, and the weight ratio of yeast to the rice.

The process in making bioethanol had been studied by Kilonzo et al. [3]. That study about direct ethanol fermentation of soluble starch or dextrin with the amylolytic yeast *Saccharomyces diastaticus*. The investigation in batch free and immobilized cells systems. In batch fermentations, the cells fermented high dextrin concentrations more efficiently. More than 92 g/l of ethanol was produced from 240 g/l of dextrin, at a conversion efficiency of 90%. The conversion efficiency decreased to 60% but a higher final ethanol concentration of 147 g/l was attained with a medium containing 500 g/l of dextrin. *S. diastaticus* in an immobilized cell bioreactor produced 83 g/l of ethanol from 240 g/l of dextrin, corresponding to an ethanol volumetric productivity of 9.1 g/l/h [3].

Shanavas et al. [4] studied in making bioethanol from cassava (*Manihot esculenta*

Crantz), bioethanol production from cassava starch using new enzymes like Spezyme® Xtra and Stargen™ 001. The liquefying enzyme Spezyme was optimally active at 90 °C and pH 5.5 on a 10% (w/v) starch slurry at levels of 20.0 mg (280 Amylase Activity Units) for 30 min. Stargen levels of 100 mg (45.6 Granular Starch Hydrolyzing Units) were sufficient to almost completely hydrolyze 10% (w/v) starch at room temperature (30 ± 1 °C). Ethanol yield and fermentation efficiency were very high (533 g/kg and 94.0% respectively) in the Stargen + yeast process with 10% (w/v) starch for 48 h. Raising Spezyme and Stargen levels to 560 AAU and 91.2 GSHU respectively for a two step loading [initial 20% (w/v) followed by 20% starch after Spezyme thinning]/initial higher loading of starch (40% w/v) resulted in poor fermentation efficiency. Upscaling experiments using 1.0 kg starch showed that Stargen to starch ratio of 1:100 (w/w) could yield around 558 g ethanol/kg starch, with a high fermentation efficiency of 98.4%. The study showed that Spezyme level beyond 20.0 mg for a 10% (w/v) starch slurry was not critical for optimizing bioethanol yield from cassava starch, although an initial thinning of starch for 30 min by Spezyme facilitated rapid saccharification–fermentation by Stargen + yeast system. The specific advantage of the new process was that the reaction could be completed within 48.5 h at 30 ± 1 °C [4].

Ragi tape (or tape yeast) is original Indonesian yeast, usually is used in starch fermentation.The yeast contains *Amylomyces rouxii*, *Candida pelliculosa* , *Saccharomyces cerevisiae*, *Hansenula anomala*, *Bacillus* and *Acetobacter* [1]. Cronk *et al*. [2] had studied about production of higher alcohols during Indonesian tapé ketan fermentation. The study was made of the higher alcohols (fusel oils) produced using *Amylomyces rouxii* as the principal mold, alone or in combination with yeasts belonging to genera commonly found in the tapé ketan fermentation (*Endomycopsis, Candida*, and *Hansenula*). Total fusel oils increased with length of fermentation. Fusel oils detected in the product distillate included isobutanol and isoamyl and active amyl alcohols. No *n*-propanol was detected. Isobutanol and isoamyl alcohols were formed in the largest amounts [2].

Siebenhandl et al. [5] studied on *tape ketan,* an Indonesian fermented rice food. Preparation of a tape ketan starter material called *ragi tape* was described by using pure cultures of *A. rouxii*, *S. cerevisiae*, *P. anomale* (HA 122) and *P. anomale* (HA 893) grown on rice. In a fermentation experiment this self-produced *ragi tape* was compared with a commercial available *ragi tape* (NKL). In addition to that, the growth of fungi, yeast and bacteria as well as the biochemical changes during the fermentation process of *tape ketan* were monitored. To do this, samples were taken periodically after 0, 5, 10, 15, 24, 36, 48 and 60 h fermentation with a commercially available starter (Tebu) at 30°C. Results show that a palatable product was ready for consumption after 48 h. Finally, *tape ketan* was prepared using two different samples of Indonesian *ragi tape* (Tebu) as inoculum and the products were compared by their nutritional constituents [5].

2 Research Methods

This research had been carried out experimentally in the laboratory of Chemical Engineering, Ahmad Dahlan University, Yogyakarta. Raw materials were cooked rice and tapé yeast. Rice was obtained from one of the food stalls around campus III Ahmad Dahlan University, Yogyakarta. *Ragi tape* (yeast) obtained from one of the convenience store in Yogyakarta. Other materials were technical alcohol, Whatman filter paper and distilled water, all were obtained from the Laboratory of Chemical

Engineering, University Ahmad Dahlan. The apparatus were standard glassware in the laboratory, plastic jars, analytical balance, Buchner funnel, vacuum pumps, distillation flask and picnometer.
Two hundred grams of rice which had 12 and 24 hours after cooking put in plastic jar that clean and dry. Yeast powder 1 to 6 grams, put in the jar that already contains rice, then mixed and closed. Let the fermentation process occurs at room temperature. The fermentation process carried out for 4 to 27 days. After the fermentation completed, all materials poured into the distillation flask. The distillation process was arranged at a temperature of 78-82 °C, for 2 to 3 hours.

3 Results and Discussion

3.1. Variable of Rice Age

The rice age was 17 and 21 hours after cooking, fermentation time 7 and 11 days, 200 g rice, and 3 and 4 grams of yeast. After fermentation completed the mixture was filtered using a Buchner funnel equipped with a suction pump (vacuum). The filtrate was weighed and measured its volume. The ethanol content were analyzed using the method of determining specific gravity, that using a digital balance and picnometer. The density of the filtrate mostly above 1.00, so beyond the range of the standard curve (0.802 to 0.996). The results are listed in Table 1.

Table 1 The results of rice fermentation (200 g of rice) without distillation

Rice age, hours	Fermentation time, hari	Yeast weight, g	Density, g/ml
17	7	3	1.01249
	11	3	1.00491
	7	4	0.91815
21	7	3	1.00322
	11	3	1.00491
	7	4	1.00070

Sources: primary data with processing, 2009.

This research was also undergone with the cooked rice age 12, 16, 20, and 24 h, weight of cooked rice 200 g, yeast 1, 2, 3, 4, 5, and 6 grams, fermentation time from 4, 5, 6, 7, 8, and 9 days. All of the fermentation results poured into the distillation flask, and the distillation process is carried out for 2-3 h at a temperature of 78-82°C. However, only two samples gave results, which 12 h (yeast 5 g, fermentation 9 days) gave 0.4 ml distillate, and 20 h (yeast 3 g, fermentation 8 days) resulted 0.3 ml distillate.

3.2. Fermentation time

The qualitative results of the fermentation can be seen in **Table 2** below.

Table 2 Qualitative data of rice age 12-24 hours, 200 g, 1-6 grams of yeast.

Fermentation time, days	Fermentation flavor	Distillate	Flavor of distillate
4	No	No	No
5	less alcohol	No	No
6	less alcohol	No	less alcohol
7	alcohol	less, not measured	alcohol
8	alcohol	yes	alcohol
9	alcohol	yes	alcohol

Sources: primary data, 2009.

From **table 2** it could be seen that ethanol was characterized by the smell (like alcohol), began to form in the long fermentation of 5 days, but the distillate could not measured. Distillate that could be obtained only in combination (age of cooked rice 12 hr, yeast 5 g, fermentation 9 days), and (age of cooked rice 20 hr, yeast 3 g , fermentation 8 days).

For the long fermentation of 20 days or more by age of cooked rice 24 hr, cooked rice 150 g, 1 gram of yeast, obtained the following results:

Table 3 Effect of Fermentation Time to The Distillate.

Fermentation time, days	Volume of distilat, ml	Ethanol,%
20	1.7	87.99
21	1.8	71.96
27	1.3	78.18

Sources: primary data with processing, 2009.

3.3. Weight Ratio of Yeast to Rice

Effect of weight ratio of yeast to rice is shown in **table 4** and **figure 1**.

Table 4 Effect of weight ratio to ethanol content.

$\frac{Yeast}{Rice}$, g/g	Density, g/ml	Ethanol, %
0.0067	0.9743	14.96
0.0133	0.9937	5.74
0.0150	0.9930	6.06
0.0250	0.9942	5.50

Sources: primary data with processing, 2009.

From the graph it can be seen that the best results on the weight ratio of yeast to the rice 0.0067.

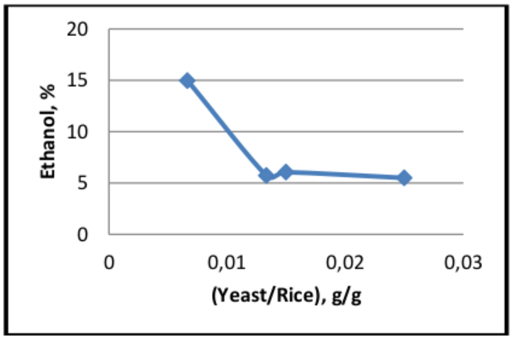

Figure 1
Effect of Yeast Rice Ratio to ethanol results

Conclusion

From the research, it can be concluded that bioethanol can be made from leftover rice, fermented using *ragi tape* (tapé yeast). The result was few quantitatively, can be harvested from the fermentation time of 8 days to 27 days. Maximum age of cooked rice that can be used 24 hours. Weight ratio of rice yeast is relatively good at 0.0067.

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