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# The Use of Durian Peel Wastes for Bioethanol Production

**Soeprijanto*, Ady Prima A, Irene Fransisca T, M.Ibrahim AH, and Inayah Wulandari**

Department of Industrial Chemical Engineering, Faculty of Vocational Studies, Kampus ITS Sukolilo, Surabaya - 60111, Jawa Timur

**E-mail:* s.soeprijanto@gmail.com

**Abstract**

*Durian peel (Durio zibethinus Murr) is one of most agricultural residues that have a percentage of approximately 60-75% and inner durian peel (soft layer) contains 11.78% starch that can be used as raw material for ethanol production. This study aimed to determine the effect of durian peel concentration on bioethanol production and the fermentation time required for bioethanol yield. Bioethanol production was carried out in a batch reactor. Two steps of liquefaction and saccharification were carried out to obtain reducing sugar. In liquefaction, 200 g durian peel flour and α-amylase were mixed with water in an Erlenmeyer 2 litter then was heated at 90°C for 2 hours. In saccharification, this mixture was then heated at 60°C for 4 h. The sugar obtained was then fermented by adding yeast as much as 0.2%; urea 0.5%; $KH_2PO_5$ 0.5% of the amount of reducing sugar obtained. Bioethanol was obtained by fractionation distillation of the fermentation at 78°C. The results showed that in the saccharification using flour with a concentration of 10, 20, 30, and 40% (w/v) produced reducing sugar of 22.23, 44.25, 55.45, and 84.61 g/l, respectively. Bioethanol in the fermentation process was 1.9, 3.6, 5.2, and 7.3%, respectively. It concluded that maximum bioethanol was obtained approximately 7.3% with the reducing sugar used at 84.615 g/l during 4 d fermentation. The bioethanol content obtained was 95% after fractionation distillation.*

***Keywords**: bioethanol, durian peel, fermentation, liquefaction, saccharification.*

## Introduction

The development of world energy needs at this time is increasingly limited by fossil energy reserves and concern for environmental preservation, causing increased attention to renewable energy, especially towards renewable energy sources from the agricultural sector.

Almost all cultivation commodities in the agricultural sector can produce biomass as a source of materials that can be converted into renewable energy. Biomass is all organic material that is relatively young and comes from plants/animals; cultivation industry products and wastes (agriculture, plantation, forestry, livestock, fisheries), which can be processed into bioenergy (Reksowardojo and Soeriawidjaja, 2006).

One form of bioenergy produced is in the form of bioethanol. Bioethanol can be produced from plant raw materials that contain carbohydrates or cellulose which are renewable. Bioethanol is a group of four organic alcohols (the other three are methanol, butanol, and propanol (isopropanol), all of which are very attractive as a fuel for vehicle engines. Bioethanol is a flammable fuel that is complete oxidation. The results of burning ethanol are carbon dioxide, water, and heat. Burning ethanol does not produce carbon monoxide, unlike gasoline or diesel fuel, but carbon dioxide emissions are higher. This is not considered a serious material because carbon has been pulled from the air by feedstock, so no net is released. $NO_x$ gas emissions produced during combustion are also lower. Bioethanol has properties similar to petroleum and is often used as a substitution or in part for petroleum. Bioethanol can be used as blending gasoline up to 5% without modification.

Agricultural residues are also a source of raw materials for producing bioethanol. Bioethanol is a chemical produced from plant raw materials that contain starches such as cassava, sweet potatoes, sorghum, corn, and sago. As well as ingredients that contain sugar and cellulose through a process of fermentation and distillation. So there is a great opportunity to be able to replace petroleum. The advantage of using bioethanol as fuel is that bioethanol has a higher octane value than gasoline (Putnarubun, 2012; Soeprijanto, 2013). One residue of agricultural products is durian peel waste. Yields of durian in Indonesia according to the Central Statistics Agency (BPS) in 2018 reached around

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2,764,256 tons. The total weight of the fruit consists of three parts including fruit flesh around 20-35%, seeds 5-15% and the rest is the skin reaches 60-75%. People only consume the fruit, while the durian peel and seeds are thrown away so that it becomes waste and pollutes the environment. In season durian peel waste reached 100 tons per day (Desi Mustika Amaliyah, 2014). The utilization and reprocessing of food waste are very important to minimize the production of waste in the food industry and provide added value from the waste. Utilization and processing of agricultural residues are very important to reduce the amount of waste in the food industry and provide added value from the waste.

The hydrolysis reaction of starch and water will produce glucose, water will attack starch on bonds 1-4α glucoside yielding dextrin, glucose depending on the degree breaking of the inner polysaccharide chain pat. However, the reaction between water and starch occurs so slowly that the use of a catalyst is needed for increasing water activity. The catalyst used can be either an acid or an enzyme. The commonly used acid catalysts are hydrochloric acid, nitric acid, and sulfuric acid. The hydrochloric acid is widely used as a catalyst in industries. This selection is based on that salt formation after neutralization results are not dangerous for health. Glucose is a monosaccharide which is one of the most important carbohydrates used as raw material for producing ethanol. Hydrolysis reactions are as shown in Equation 1.

$$(C_6H_{10}O_5)_n + n\ H_2O \rightarrow n(C_2H_{12}O_6) \quad (1)$$

In the fermentation of ethanol, there are 4 main products, such as division of yeast cell, $C_2H_5OH$, $CO_2$, and heat. Hydrolysis of one mole of glucose will produce stoichiometry, 2 moles of $C_2H_5OH$, and 2 moles of $CO_2$ as shown in Equation 2 and 3. Based on a mass, 1 g of $C_6H_{12}O_6$ consumed for energy purposes will theoretically produce 0.51 g of $C_2H_5OH$ and 0.49 g of $CO_2$. However, in practice, a part of the glucose is consumed to produce new cells (Soeprijanto, 2013; Soeprijanto *et al.*, 2019).

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 \quad (2)$$

$$C_6H_{12}O_6 \rightarrow C_2H_5OH + 2\ CO_2 \quad (3)$$

Ginting dkk (2018) showed The highest concentration of ethanol obtained from their experiment was obtained 8.5% at a concentration of 5% $H_2SO_4$ for chemical treatment.

The purpose of these experiments was to study the effect of durian skin flour concentration, and the effect of optimal fermentation time needed to produce ethanol.

## Materials and Methods

***Materials.*** Durian peel was obtained in the Barata Jaya area, W.R. Supratman, and supermarkets (Giant, Super Indo, Carrefour) in Surabaya as shown in Figure 1. A part of the skin used was the inner durian peel. Chemicals such as HCl, $CaCl_2$, $KH_2PO_4$, urea were purchased at the Chemical Shop Pucang Anom, Surabaya. *Saccharomyces cerevisiae* (yeast) was purchased at the Giant Supermarket. α-Amylase and Glucoamylase enzymes were obtained from PT. Sorini Agro Asia Corporindo, Pasuruan Regency.

**(a)** **(b)** **(c)**

**Figure 1**. Raw material of durian peel. *Note*: (a) = Durian peel; (b) = inner durian peel; (c) = dried ground inner durian peel.

**Experimental Setup**

***Enzymatic Hydrolysis.*** Hydrolysis is the process of converting complex polysaccharides into simple sugars. The process of starch hydrolysis with enzymes is carried out through 2 stages, namely the liquefaction process by the α-amylase enzyme and then followed by the saccharification process by the glucoamylase enzyme.

***Liquefaction Process.*** In the liquefaction process (Figure 2), durian skin powder of 200-800 g was put in the Erlenmeyer 2000 ml and was added with water up to 2000 ml. The pH was adjusted between 6-6.4 and added with HCl solution. the α-amylase enzyme was added as much as 3 ml and $CaCl_2$ 40 mg/l as an enzyme stabilizer. The slurry was then heated to a temperature of 90-100°C for 2 h while stirring. Finally, the sugar content was analyzed using Lane and Enyon methods.

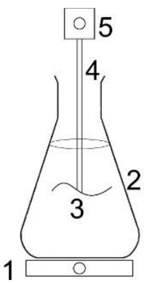


**Figure 2**. Liquefaction of durian peel flour for sugar production using α-amylase. *Note:* 1 = hot plate; 2 = Erlenmeyer; 3 = Slurry of durian peel flour; 4 = propeller stirrer; 5 = stirrer motor.

***Saccharification Process.*** In the saccharification process (Figure 3), the slurry obtained at the liquefaction was cooled to 60°C, then the pH was adjusted to 4.5-5 by adding 1N HCl. Then the glucoamylase enzyme was added as much as 3 ml and heated at 60°C for 4 h while stirring. Then the slurry was cooled to room temperature and filtered to separate the solids to take the filtrate. The sugar obtained was then analyzed using Lane and Enyon methods.

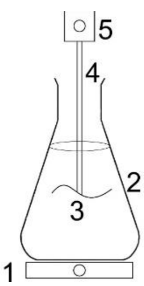


**Figure 3**. saccharification of durian peel flour for sugar production using α-amylase. *Note:* 1 = hot plate; 2 = Erlenmeyer; 3 = Slurry of durian peel flour; 4 = propeller stirrer; 5 = stirrer motor.

***Fermentation.*** The fermentation process as shown in Figure 4 is intended to convert sugar into ethanol/ bioethanol using yeast. *Saccharomyces cerevisiae* was added 0.3% of sugar, urea, and $KH_2PO_4$ 0.5% of the sugar content and then mixed with stirring. Then the fermentation process was carried out for 3 d.

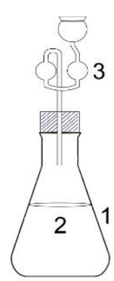


**Figure 4**. Batch fermentation of ethanol using *Saccharomyces cerevisiae* baker yeast. *Note:* 1 = fermenter; 2 = slurry of durian skin flour; 3 = channel of $CO_2$ gas produced.

***Distillation stage.*** Distillation was done to separate ethanol from excess water. The temperature for this distillation was set approximately 80°C because at that temperature closely the boiling point of ethanol. Then the content of ethanol was analyzed using Gas Chromatography.

***Determination of Reducing sugar.*** The Lane and Enyon method (ISI, 1999) is used to determine glucose concentration. Ten ml mixture of Fehling A and Fehling B solution was put into Erlenmeyer and added with 4 drops of methylene blue with a concentration of 10 g/l. Then the solution is heated to boiling. During boiling, a standard glucose solution at a concentration of 5 g/l is added from the burette until the blue color disappears to brick red. The titration is repeated using a sample solution. Glucose concentration in the sample was calculated as seen in Equation (1).

$$C_{smpl} = \frac{C_{std} \text{ x } V_{std}}{V_{smpl}} \left(\frac{g}{l}\right) \quad (1)$$

Where:

$C_{spl}$ = sample concentration, g/l
$V_{spl}$ = sample volume, ml
$C_{std}$ = standard concentration, g/l
$V_{std}$ = standard volume, ml

## Results and Discussion

### *Liquefaction*

The production of reducing sugar on the liquefaction by the α-amylase enzyme using flour of 10, 20, 30, and 40%, respectively is shown in Figure 5. The results showed sugar production increased with the increase in the addition of durian peel flour concentration. The use of a concentration of 10, 20, 30, and 40% (w/v) of durian peel flour, the reducing sugar produced was 4.35, 4.66, and 4.93 g/l, respectively. The maximum reducing sugar concentration achieved was 4.93 g/l with a durian flour concentration of 40% (w/v). This is due to the high levels of starch which were converted into sugar by enzyme activity.

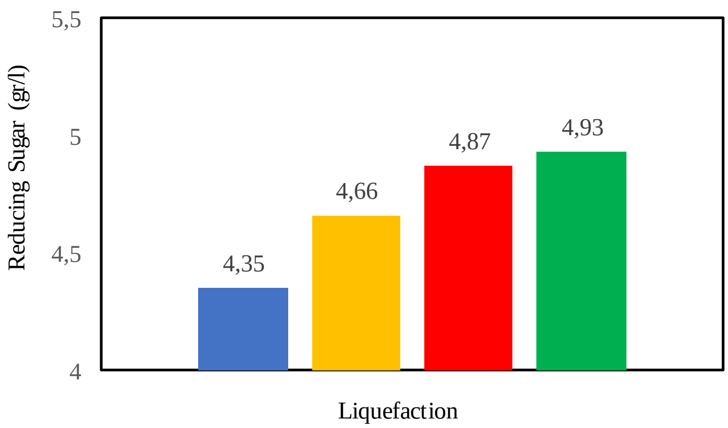


**Figure 5**. Effect of durian flour concentration on reducing sugar content in the Liquefaction. *Note:* ■ = durian peel flour of 10%; ■ = 20%; ■ = 30%; ■= 40%.

### *Saccharification*

Figure 6 shows the effect of a variety of durian flour concentration using 10, 20, 30, and 40% on the reducing sugar production in the saccharification process by glucoamylase enzymes. The results showed sugar production increased with the increase in the addition of durian skin flour concentration. The use of 10, 20, 30, and 40% (w/v), the reducing sugar produced was 22.12, 44.21, 55.14 g/l, and 84.62 g/l. The maximum sugar content achieved was 84.62 g/l with a durian flour concentration of 40% (w/v). This is due to the high levels of starch which are converted into sugar by enzyme activity.

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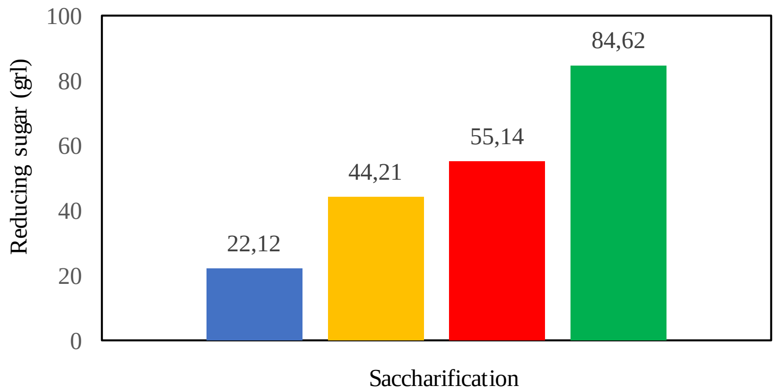


**Figure 6.** Effect of durian flour concentration on sugar content in the saccharification. *Note:* ■ = durian peel flour of 10%; ■ = 20%; ■ = 30%; ■ = 40%.

***Effect of sugar concentration on ethanol production***

The main factor to obtain high ethanol productivity depends on the amount of sugar produced in the enzymatic hydrolysis process using *Saccharomyces cerevisiae*. Figure 7 shows the correlation between reducing sugar reduction and ethanol production. The results indicated that ethanol production was influenced by reducing sugar concentration. The ethanol concentration produced increased from 0.3, 0.7, 1.5, and 1.9% by increasing the amount of reducing sugar used from 3.36, 7.53, 15.13, and 20.15 g/l at a concentration of 10% (w/v) durian flour. The ethanol increased from 1.2, 1.7, 2.4, and 3.6%, respectively with an increasing amount of sugar used from 12.57, 19, 25.35, and 36.14 g/l at a concentration of 20% durian flour. The ethanol increased from 0.9, 1.4, 3.6, and 5.2%, respectively with an increasing amount of sugar used from 9,71, 16,88, 37.21, and 54,23 g/l at a concentration of 30%. Ethanol increased from 1.8, 3.2, 5.7, and 7.3% with an increasing amount of sugar used from 23.50, 38.78, 58.43, and 73.62 g/l at a concentration of 40% durian flour. The maximum ethanol was achieved by 7.3% on with a flour concentration of 40% (w/v) for 4 d. This is due to the sugar levels that have been consumed by *saccharomyces cerevisiae* are converted to ethanol and on the fourth day, the bacteria undergo a stationary phase where bacterial growth decreases because the nutrients in the sample are fewer and the bacteria die.

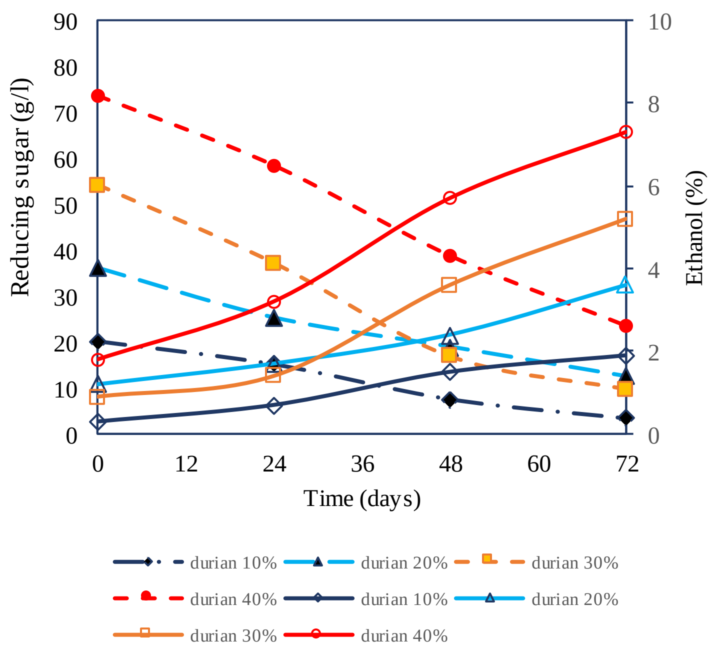


**Figure 7.** Effect of reducing sugar concentration on ethanol production. *Note:* ● = Reducing sugar (0.5% enzyme); ■= Reducing sugar (0.2%); ○ = ethanol (0.5%); □ = ethanol (0.2%).

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## Conclusions

It concluded that the maximum reducing sugar obtained was 4.93 g/l with a durian flour concentration of 40% (w/v) in the process liquefaction, and was 84.62 g/l in the saccharification process. The maximum ethanol content was obtained by 7.3% with a durian flour at a concentration of 40% (w/v) for 4 d.

## Acknowledgment

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## List of Notation

$C_{spl}$ = sample concentration [g/l]
$V_{spl}$ = sample volume [ml]
$C_{std}$ = standard concentration [g/l]
$V_{std}$ = standard volume [ml]
$P$ = pressure [atm]
$T$ = temperature [°C]
$t, d$ = time [second, hour, day]

## References

Dewati R, Wahyusi KN, Dewi CP. Kinetika reaksi hidrolisa kulit durian menjadi glukosa dengan katalisator HCl pada tangki berpengaduk. 2010.

Ginting SN, Simanullang EK, Simanullang LP, Nainggolan B, Silaban S. The optimization of acid hydrolysis on bioethanol production from durian peel waste (*durio zibethinus murr*). Jurnal Pendidikan Kimia 2018; 10: 382-386.

Jayanti RT. Pengaruh pH, suhu hidrolisis enzim a-amilase dan konsentrasi ragi roti untuk produksi etanol menggunakan pati bekatul. 2011.

Lumbantorua DIP, Ginting S, Suhaidi I. Pengaruh konsentrasi bahan pengendap dan lama pengendapan terhadap mutu pektin hasil ekstraksi dari kulit durian. Jurnal Rekayasa Pangan dan Pert. 2014; 2 (2): 58-64.

Obeng A, Premjet D, Premjet S. Fermentable sugar production from the peels of two durian (durio zibethinus murr.) cultivars by phosphoric acid pretreatment. Resources. 2018; 7 (4): 1-15. DOI: 10.3390/resources7040060.

Reksowardojo IK, Soerawidjaja TH. Teknololgi pengembangan bioenergi untuk industri pertanian. Dalam: Agung H, Sardjono, TW Widodo, P Nugroho, Cicik S. Proc. Seminar Nasional Mekanisasi Pertanian : Bioenergi dan Mekanisasi Pertanian untuk Pembangunan Industri Pertanian 2006.

Soeprijanto. Teknologi pengembangan Bioetanol dari Biomassa Sorghum. Surabaya: ITS Press. 2013.

Soeprijanto, Adiwarna PDW, Faristi SD, Agata MM, Budianto MI. Production of bioethanol from solid wastes of tapioca flour industry through enzymation and fermentation process. Prosiding Seminar Nasional Teknik Kimia "Kejuangan". 2019.

# Lembar Tanya Jawab

**Moderator : M. Maulana. Azimatun Nur (UPN "Veteran" Yogyakarta)**
**Notulen : Indriana Lestari (UPN "Veteran" Yogyakarta)**

1. Penanya : M. Maulana Azimatun Nur (UPN "Veteran" Yogyakarta)
   Pertanyaan : Apakah pernah diuji dengan konsentrasi di atas 40%?
   Berapakah kadar gula pada tepung durian?
   Jawaban : Belum pernah dilakukan, karena terkendala pandemi.
   Kadar gula pada tepung durian sekitar 50 – 60% yang berbentuk selulosa dan kandungan lainnya yaitu 5% elemen tepung dan lignin.

2. Penanya : Bismantiyo Kumolo (UPN "Veteran" Yogyakarta)
   Pertanyaan : Mengapa dipilih enzim α-amilase dan dapatkah menggunakan enzim yang lain?
   Jawaban : Karena pada penelitian ini enzim yang digunakan disuplai dari PT Sorini.
   Bisa digantikan dengan enzim yang lain, namun tetap memperhatikan jenis karbohidrat yang akan dikonversi.

3. Penanya : Joni Setiawan (Balai Besar Kerajinan dan Batik)
   Pertanyaan : Bagaimana cara memenuhi kebutuhan bioetanol jika permintaan dalam kondisi baik dan ketersediaanya seperti apa?
   Jawaban : Pembuatan bioetanol dari kulit durian ini masih dalam tahap penelitian sebagai upaya penanganan limbah kulit durian saat panen puncak.

4. Penanya : Dini Avriliani (Universitas Riau)
   Pertanyaan : Apakah jenis *yeast* yang digunakan adalah ragi instan atau *yeast* yang perlu dikultur?
   Jawaban : Jenis *yeast* yang digunakan adalah *yeast* kue dengan merek fermipan.