Implementation of Experimental Designs to Improve Bioethanol Quality From Banana Beans Through the Destilation Process

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Abstract. This experimental research is arranged in a $2^3$ factorial form using a tolerance level (\(\alpha\)) of 5\% so that the rejection zone rule will lie at the p-value of the anova output, the length of fermentation incubation time and the average yield of the type of substrate and alcohol content, type of substrate against long fermentation. The interaction plots of substrate types of banana king hump, banana kepok hump, banana milk hump and fermentation time are 96 hours, 144 hours, 196 hours. The output of banana king hump substrate has a mean low quality level of 55,720 fermentation time of 96 hours, the output of banana king hump substrate, the mean level of medium quality, average alcohol content is the mean value of 61,648 fermentation time of 144 hours. Interaction factor of alcohol content, mean best quality level, average alcohol content of banana king hump substrate mean 62,503 fermentation time 196 hours. The best quality bioethanol content level is the type of substrate of banana king hump, fermentation time of 196 hours.

1. Introduction

Oil fuel is one of the most important energies in the world, the production of this fuel increases with increasing consumption, but the limited oil reserves will reduce production so that efforts are needed to obtain alternative fuels (Kerr, 1998). Among the alternative fuels, namely from vegetable, which can be developed into biodiesel and bioethanol because these two fuels can take advantage of geographical conditions and sources of vegetable oil raw materials from various plants available in Indonesia (Riyanti, 2009). According to the Agency for the Assessment and Application of Technology (BPPT), Indonesia has 60 types of plants that have the potential to become alternative fuel energy (Shintawaty, 2006). The Government of the Republic of Indonesia has programmed a design that is to use agricultural wastes as a substitute for premium or what is known as bioethanol (Mulyani & Las, 2008). The need for bioethanol consumption as a fuel is a target in many countries, because the results of combustion are environmentally friendly, high octane value and more importantly, biomass raw materials are available in the country respectively in the form of agricultural products and various agricultural, plantation, and processing wastes. forestry, municipal waste and other biomass The large potential starch content of banana weevils can be used as raw material for making alternative root materials, namely starchy bioethanol, which is used as raw material for bioethanol, is recommended to have properties, namely high starch content, high yield potential, flexibility in farming and harvesting age (Yuanita & Rahmawati, 2008). According to (Solikhin et al., 2012) said that the production of bioethanol from the hydrolysis of banana weevils by fermentation using Saccaromycess Cereviceae with variations in the...
addition of a starter and fermentation time obtained the highest ethanol content in the starter 4%, 4 days fermentation is 10.03% v/v, for 6% starter, 5 days fermentation is 11.65% v/v, and for 8% starter, 5 days fermentation is 12.20% v/v. According to (Warsa et al., 2013) said that the manufacture of bioethanol from banana weevils by hydrolysis and fermentation processes where this hydrolysis uses alpha-amylase enzymes and gluco-amylase enzymes then followed by a fermentation process using Saccharomyces cerevisiae produces the best results obtained using concentrations 9% starter and 7 days fermentation time, the resulting bioethanol content is 30.59%, meanwhile (Nuha & Luthfianto, 2015) states that from the experimental results on the waste of Kepok banana peels and johar wood sawdust has a high calorific value, at Sweet potato fermented using baker's yeast produces good ethanol (Moede et al., 2017) by fermentation for 4 days (Nasrun et al., 2017) and by adding the banana stone peel waste media which is influenced by the concentration of baker's yeast will produce sufficient bioethanol high (Febriana et al., 2018). Research conducted by (Junaini et al., 2019) states that the effect of the use of various types of banana weevil on the levels of bioethanol obtained and all types of banana weevils can be used as bioethanol. From some of the studies above, there are several experimental methods that underlie it, but in this study, the design of bioethanol from banana weevil has not been estimated with 2 factors that affect the results of bioethanol levels, namely the type of substrate used as bioethanol making material and the fermentation process. type of substrate to maximize the yield of bioethanol content in 3 levels for each type of substrate.

2. Research Methods

2.1. Tools and Materials

a) Tools
The tools used in this research are digital scales, digital thermometer, panic presto, LPG gas, gas stove, ac pipe, 3.5" pvc pipe, 2 pvc pipe cover, (fermentation place), filter paper, distillation unit, measuring cup.

b) Material
The materials used in this study were 3 types of banana weevil, namely plantain weevil, banana weevil and milk banana weevil, yeast, NPK fertilizer, urea fertilizer.

2.2. Experiment

a) Media Preparation
1. Prepare 3 types of banana weevils, namely plantain weevils, banana weevils, and milk banana weevils that have been harvested around the age of 3-4 months.
2. Clean the skin as well as those that are taken inside the tub and then wash it thoroughly.
3. Weighing the weevil according to the treatment sample with the weight of each sample 30 kg for each type of banana weevil sample.
4. Cook 5 liters of water then add the banana weevil until it becomes puree and cook at 100° C.
5. Then the banana weevil pulp is cooled to a temperature of 30° C.

b) Fermentation Stage
1. After the filtrate is cold, then put the 4000 ml sample into a sterilized fermentation container.
2. Adding 20 grams of yeast, 30 grams of urea, 7 grams of NPK fertilizer.
3. The bottle is closed tightly then given a hole and a water hose is installed for the recovery process so that the alcohol that is involved in the CO2 gas flow is captured by the Water Scrubber (oxygen catcher) which is attached to the container lid.
4. Furthermore, the samples were fermented according to the treatment time, namely 96 hours, 144 hours, and 196 hours.

c) The Process of Making Bioethanol
After the fermentation time according to treatment ends, the fermentation results are then distilled.
and carried out according to the analytical procedure. As for the distillation process, first the samples from the fermentation incubation results are filtered, then the filter results (each sample 2500 ml) are put into a pan to carry out the distillation process at a temperature of 92 ºC. The distillation is stopped when no filtrate has dripped off.

2.3. Method

The research method used was a pure experiment using a randomized block design (RBD) which was arranged in a factorial consisting of two factors with 3 replications. The design of bioethanol from banana weevils predicts that there are 2 factors that influence the highest bioethanol content, namely the type of substrate used for bioethanol production and the fermentation process. The type of substrate used in the manufacture of bioethanol conducted research on 3 types of banana weevils. The experiment tested 3 types of banana weevil at each level combination for each type of substrate and the long process.

2.4. $2^3$ Factorial Experiment Design

The $2^3$ factorial design method estimates that there are 2 factors that influence the results of the highest bioethanol content and the fermentation time factor of 5 days to 7 days, the experiment identified 3 types of substrate to maximize the yield of bioethanol content in 3 levels for each type of substrate. The type of substrate used in the manufacture of bioethanol conducted research on 3 types of banana weevils. In the experiment, 3 types of banana weevil were tested in each combination of substrate type levels and the long process of incubation fermentation. intended to determine which of a number of factors has the best potential effect on the efficiency response in producing bioethanol at the level of the composition of the raw materials used.

3. Research Results and Discussion

3.1. Research Results

| Table 1. Factorial Design Average value of bioethanol making design (%) from banana hump with 3 types of substrate treatment and fermentation time |
|-----------------------------------|---------------|---------------|---------------|
| Type of Substrate                | Fermentation Time |               |               |
|                                  | 96 hour        | 144 hour      | 196 hour      |
| Banana king hump                 | 57,30          | 62,68         | 63,62         |
|                                  | 56,10          | 61,72         | 62,49         |
|                                  | 55,28          | 61,64         | 62,35         |
|                                  | 54,20          | 60,55         | 61,55         |
|                                  | 56,70          | 60,78         | 62,55         |
|                                  | 55,30          | 60,02         | 61,49         |
| Banana kepok hump                | 54,18          | 59,64         | 60,25         |
|                                  | 53,12          | 59,25         | 59,45         |
|                                  | 55,30          | 60,78         | 61,12         |
| Banana milk hump                 | 54,10          | 59,02         | 59,94         |
|                                  | 53,28          | 58,64         | 59,51         |
|                                  | 52,20          | 58,25         | 58,37         |

(Source: Laboratory test results alcohol content, 2018)
3.2. Discussion

a) Data Normality Test Results

From Figure 1, information is obtained that the data has a normal distribution, it can be seen from the P-Value value of 0.150 of the F distribution $> \alpha = 0.05$. The normality test value for alcohol content obtained is 0.150 and the data has a different percent for each respondent / subject.

b) Data Homogeneity Test Results

The data is homogeneous if the P-Value is greater than 0.05 and the slices are not blank, all samples (three samples in the figure) must be intersected. Because in the picture we see that the samples are
intersected, the data is homogeneous. Performed the homogeneity test to examine the effect of the type of substrate on alcohol content with a P-Value value of 0.741 greater than the F distribution ($\alpha = 0.05$).

c) **Average Value for Alcohol Content**

![Main Factor Plot](image)

**Figure 3.** Main Factor Plot

(Source: Output Data using Minitab 14)

Figure 3 is a graph of the average alcohol content of the type of substrate and fermentation time. The third type of substrate and the fermentation time of 196 hours had a big influence on the alcohol content. Both types of factors have opposite effects with the type of substrate of banana king hump which have a major influence on the alcohol content of bioethanol.

d) **Plot of Interaction Between Factors**

![Interaction Plot](image)

**Figure 4.** Plot of Interaction Between Factors

(Source: Output Data using Minitab 14)

The output of the graph above is the interaction of the two factors, to evaluate the interaction plot between the factors, the average uniformity test is carried out based on certain factors, the average uniformity test is described in Figure 5.
e) Pairwise Comparisons Test

Average Type of Substrate Test for 196 hours of Fermentation

![One-way ANOVA: jenissubstrat versus loma fermentasi_196](source)

**Figure 5.** ANOVA Type of substrate versus 196 hour fermentation time (Source: Output Data using Minitab 14)

f) Hypothesis

The hypothesis is:

$H_0$ : The average alcohol content in the fermentation time was 96, 144, and 196 hours the same.

$H_1$ : The average alcohol content in the fermentation time 96, 144, and 196 hours was not the same.

g) Area of Rejection

Data analysis used a tolerance level ($\alpha$) of 5% so that the rejection area rule would be located at a p-value less than $\alpha$. So, if the p-value falls in this area, then the conclusion is to reject the initial hypothesis that the average alcohol content of each type of substrate is the same.

Interpretation of Fisher's Test Output

1. Type of substrate for 96 hours fermentation

By using a tolerance level ($\alpha$) of 0.05 from the output, the output average value of alcohol content, the type of substrate type of plantain weevil at 96 hours fermentation time, the mean value was 55.720.
The type of substrate type of banana weevil kepok in the fermentation time of 96 hours is known the Mean value is 54.825. The output of the type of substrate type of banana milk weevil in the fermentation time of 96 hours has the mean value of 53.720. So that the factor that affects the value of the best mean level on the average alcohol content is the type of plant banana weevil substrate knowing the mean value of 55.720 at 96 hours fermentation time.

2. Type of substrate at 144 hours fermentation time

From the output of the average value of alcohol content, the output type of plantain weevil substrate at 144 hours fermentation time knows the mean value of 61.648. The output of the type of substrate of kepok banana weevil in the fermentation time of 144 hours has a mean value of 59.923. The output of the type of substrate type of banana milk weevil in the fermentation time of 144 hours has a mean value of 59.173. So that the factor that affects the value of the best mean level on the average alcohol content is the type of plant banana weevil substrate knowing the mean value of 61.648 in the fermentation time of 144 hours.

3. Type of substrate for 196 hours fermentation

From the output of the average value of alcohol content, the output type of plantain weevil substrate at 196 hours fermentation time knows the mean value of 62,503. The output of the type of substrate of kepok banana weevil in the fermentation time of 196 hours knows the mean value of 60.935. The output of the type of substrate type of banana milk weevil in the fermentation time of 196 hours knows the mean value of 59.735. So that the factor that affects the value of the best mean level on the average alcohol content is the type of substrate of plantain weevil knowing the mean value of 62,503 in the 196 hour fermentation time.

4. Conclusion

a. For the effect of the type of substrate on alcohol content, doing a hypothesis test results in F count = 13.11 > F table = 3.35 meaning that there is a significant difference between levels in the type of substrate factor on alcohol content. The effect of fermentation time on alcohol content by conducting a hypothesis test resulted in F count = 104.96 < F table = 3.35, which means that the initial hypothesis which says that the duration of fermentation affects alcohol content The effect of the interaction between factors on alcohol content by conducting a hypothesis test resulted in F count 13.11 > F Table = 2.73 F which means that there is a significant effect of the interaction between the type of substrate and the fermentation time.

b. Factors that affect the best quality bioethanol alcohol content are the type of substrate of plantain bananas fermentation time of 196 hours with a mean of 62.502%

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