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Analysis of Variances in Flame Length of Time For Maggot BSF Oil with Several Types of Oil

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ABSTRACT

Three problems are being faced simultaneously by Earth today: water (wastewater), energy, and food. However, considering the finite amount of land and the depletion of fossil fuels, this expansion is incompatible with the replenishment of natural resources in terms of both quantity and quality. Furthermore, another sustainable energy source that has gained international attention is biodiesel. However, research on the relative flash durations of Maggot BSFL oil has not been conducted. Consequently, this article will compare the flame times of many other types of oil with Maggot BSFL oil. This study uses a variety of oils as experimental subjects, including BSF maggot oil, used cooking oil, Pertamina Dex, and a combination of Pertamina Dex and BSF maggot oil. Analysis of the variations in flame time for each type of oil is done using statistical analysis. According to this analysis, the mixture of Maggot BSF oil and Pertamina Dex had the maximum flame, lasting between 16.31 and 16.44 minutes. Additionally, this study offers data on the notable variations in flame length for each type of oil, including used cooking oil, Pertamina Dex, Maggot BSF oil, and a combination of both. When creating biodiesel from Maggot BSF oil, the experiment's findings can serve as a starting point. in order for biodiesel made from Maggot BSF oil to provide Indonesia with a fresh option for the development of sustainable energy.

Keywords: Energy, fossil fuels, Maggot BSF, Flash duration, Flame, renewable energy

Introduction

The waste-food-energy (WFE) nexus, which encompasses water (wastewater), food, and energy, is an issue that Earth is currently experiencing simultaneously. By 2050, there will be nine billion people on the planet [1][2]. However, given the finite amount of available land and the depletion of fossil fuels, this increase is out of balance with the replenishment of natural resources in terms of both quantity and quality. Consequently, it is imperative to resolve this energy problem before it jeopardizes other areas in the near future. There have been attempts to get alternate renewable energy sources, including hydro [3][4], wind[5], geothermal [6], and solar [7][8]. Moreover, biodiesel is another sustainable energy source that has drawn interest from all around the world [9][10][11].

It is imperative to investigate alternative renewable energy sources in light of the environmental risks linked to the overuse of

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fossil fuels [12][13]. As an alternative to conventional diesel derived from petroleum, biodiesel—which is made from renewable resources like vegetable oils—has gained more and more attention in recent years. Triglyceride and alcohol, usually methanol, undergo a transesterification reaction that yields glycerol and fatty esters, which is biodiesel[14]. Biodiesel is an alternative fuel that doesn't require mixing with fossil fuel and may be used in commercial diesel engines without requiring further engine modifications [15]. As a result, the convenience of the user can be maintained while using renewable energy. Fatty acid methyl ester, or FAME, is the primary ingredient in biodiesel and is produced by transesterifying oils and alcohols [16] [17]. Edible and non-edible oils that have a high concentration of triacylglycerols (TAG) are often utilized feedstocks for the synthesis of biodiesel [13]. However, producing biodiesel with edible oils is expensive and could interfere with food supplies, making biodiesel less competitive in the fuel market [18]. The cost of producing biodiesel can be significantly decreased by using non-edible oils and leftover cooking oil, although these oils typically need extra processing stages. Thus, in order to lower costs and streamline the process of producing biodiesel, it is imperative to investigate novel and economical sources of oils [19].

The black soldier fly larvae (BSFL; Hermetia illucens) are gaining traction as a potential feedstock for biodiesel due to their short life cycle, high fat content, and fast reproduction rate [20]. These insects effectively convert organic waste into biomass that is high in protein and fat [21][22] by consuming a variety of waste materials, including animal manure [13], kitchen garbage [23], and lignocellulosic biomass [1, 6]. The biomass can have its fat removed and used to produce biodiesel [24]. Additionally, the leftover waste from the fat extraction process can be fed to livestock, poultry, and aquatic animals as a source of protein [23]. Due to these benefits, BSFLs are widely applicable and economically feasible.

A member of the soldier fly family, the black soldier fly has two wings. Unlike other insects, the black soldier fly has a short growth cycle and can thrive in a range of complicated settings, including kitchen trash and poultry manure [23]. It is also not a pest. The ability to inactivate pathogens and transform a significant quantity of low-value organic waste into high-value biomass is what makes them so popular in various fields, such as waste reduction [25]. The larvae of the Black Soldier Fly (BSFL) are abundant in crude proteins and lipids, comprising 35–40% and 40–44% of lipids, respectively. Saturated fatty acids (SFFA) make up the majority of the recovered lipids from BSFL, and these lipids have been utilized to produce biodiesel [26]. Lipids removed from BSFL therefore offer a potential source for the synthesis of biodiesel.

Many studies related to the use of BSFL have been carried out by researchers. However, studies related to the comparative flash time of Maggot BSFL oil have not been carried out. Thus, this article will analyze the comparison of the flame time of Maggot BSFL oil with several other types of oil.

Methods

The research was carried out at the Industrial Engineering Laboratory at Pancasila University from August – October 2023. This research used an experimental design to reach valid, effective and efficient conclusions. One method that is often used in research is Design of Experiment (DoE). DoE is a series of procedures consisting of several stages, from planning to interpretation of results. There are five basic principles in DoE, namely randomization, repetition/replication, blocking, orthogonality, and factorial experiments [9]. This research will use the principle of repetition/replication, where experiments are carried out with the same treatment to increase the precision of the experimental results. The test results were carried out on the resulting water content and then analyzed using one-way ANOVA to determine whether there were real differences between samples. One-way ANOVA is a statistical method for testing the average of 3 or more groups. One-way ANOVA is usually used when a test has only one independent variable [10]. The stages of this research are as follows:

The BSF maggots used in this research were cultivated. The BSF maggot chosen was an adult BSF maggot aged 17 days. The selection of maggots was based on the consideration that at the age of 17 days, BSF maggots contain fat which can be converted into BSF oil. BSF oil

is made using an oil pressing machine to obtain BSF maggot oil.
In the experiment to determine the duration of the flame, it was carried out through several stages:

a. Measure 5ml of each oil
b. Make a wick from cotton
c. Place the wick in the container
d. Put the oil in a container that has a wick
e. Burning wick
f. Measuring time using a stopwatch

This research method is experimental on a laboratory scale, comparing flame times for several types of oil, such as:

a. BSF Maggot Oil
b. Used Cooking Oil
c. Pertamina Dex
d. A mixture of BSF Maggot Oil and Pertamina Dex in a 1:1 ratio.

The one way ANOVA method was used to analyze the flame time with a 95% confidence level to determine whether there were differences in the means of the four samples. Further hypotheses in this research are:

$Ho: \mu A = \mu B = \mu C = \mu D = \mu E$
Ha: not all means are equal

Result and Discussion

Based on the test results on the four samples, flames were obtained from 10 replications as shown in table 1.

Table 1. Flame time for several types of oil

Samples	Time (Minute)									
	1	2	3	4	5	6	7	8	9	10
Maggot BSF oil	15,33	15,31	15,20	15,43	15,41	15,41	15,40	15,29	15,26	15,28
Used cooking oil	8,48	8,33	8,50	8,51	8,51	8,43	8,45	8,39	8,50	8,36
Pertamina Dex	8,32	8,32	8,31	8,36	8,37	8,32	8,36	8,31	8,37	8,36
A mixture of Maggot BSF and Pertamina Dex	16,35	16,31	16,44	16,41	16,41	16,31	16,37	16,35	16,29	16,39

Table 1 provides information regarding the length of flame time for several types of oil samples such as BSF maggot oil, used cooking oil, Pertamina Dex and a combination of BSF maggot oil and Pertamina Dex. Furthermore, from the test results it was obtained that the longest flame time value was the combination of Maggot Oil with Pertamina Dex, namely 16.44 minutes. Apart from that, the lowest flame duration was Pertamina Dex, namely 8.32 minutes. The time value for Pertamina Dex is almost the same as the time value for used cooking oil, namely around 8.32-8.51 minutes. What is interesting about this data is that it also provides information that pure maggot oil before being processed into biodiesel produces a fairly long flame time, namely around 15.20 – 15.51 minutes. This can be an initial conclusion that Maggot BSF oil can be converted into biodiesel oil.
Furthermore, statistical analysis was carried out to see the differences in flame time for each test sample. Statistical calculations using ANOVA are as follows below.

a. Maggot BSF vs Minyak Jelantah

Anova:Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	153,30	15,33	0,006068
Column 2	10	84,454	8,445	0,004258

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	237,02	1	237,02	45907,86	4,05E-32	4,413
Within Groups	0,0929	18	0,0051			
Total	237,11	19				

Based on the calculation results, it can be seen that the FCount value (45907.86) is greater than the Fcrit value (4.4138), so Ho is rejected, so the consequence is that the alternative hypothesis or H1 is accepted. So it can be concluded that the different types of oil

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samples have a significant influence on the flame time of the test samples.

b. Used cooking oil vs Pertamina Dex

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Ave.	Variance
Column 1	10	84,45	8,445	0,0042
Column 2	10	83,39	8,339	0,0006

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0,056	1	0,056	22,77	0,00015	4,413
Within Groups	0,044	18	0,002			
Total	0,100	19				

Based on the calculation results, it can be seen that the FCount value (22.770) is greater than the Fcrit value (4.4138), so Ho is rejected, so the consequence is that the alternative hypothesis or H1 is accepted. So it can be concluded that the different types of oil samples have a significant influence on the flame time of the test samples.

c. Maggot BSF vs Pertamina Dex

Based on the calculation results, it can be seen that the FCount value (72463.88) is greater than the Fcrit value (4.4138), so Ho is rejected, so the consequence is that the alternative hypothesis or H1 is accepted. So it can be concluded that the different types of oil samples have a significant influence on the flame time of the test samples

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Ave.	Var
Column 1	10	83,39	8,33	0,0006
Column 2	10	153,3	15,3	0,0060

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	244,37	1	244,3	72463,88	6,66E-34	4,413
Within Groups	0,0607	18	0,003			
Total	244,43	19				

d. A mixture of Maggot BSF and Pertamina Dex

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Ave.	Var.
Column 1	10	163,6	16,36	0,002
Column 2	10	153,3	15,33	0,006

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5,30	1	5,308	1243,10	4,59E-18	4,413
Within Groups	0,07	18	0,004			
Total	5,38	19				

Based on the calculation results, it can be seen that the FCount value (1243.101) is greater than the Fcrit value (4.4138), so Ho is rejected, so the consequence is that the alternative hypothesis or H1 is accepted. So it can be concluded that the different types of oil samples have a significant influence on the flame time of the test samples.

In their main body, insects store energy as glycogen and triglycerides (lipids) [27]. Since food waste serves as sustenance for insects, a range of chemical components of food waste can be converted by the metabolism of insects into lipids in their fat bodies [28][29]. Lipids serve as crucial feedstocks for the well-established industrial chemical reaction known as transesterification, which produces biodiesel. The main feedstocks for the production of biodiesel are soybeans and palm oil, which have lipid levels of 18 and 36%, respectively [30]. In comparison to oil-bearing crops, insects are known to have larger lipid contents (30–40%) or to be more competitive [31]. Furthermore, the fast pace of insect growth can quicken the food waste's transformation into lipid. Insects that feed on food waste are therefore predicted to produce large amounts of biodiesel, which can serve two purposes: (1) disposing of food waste; and (2) producing energy in the form of biodiesel through an eco-friendly procedure.

Hermetia illucens, often known as H. illucens, is a common member of the Stratiomyidae family of flies that inhabit tropical and temperate climates. The development period of black soldier fly larvae (BSFL) is three weeks, which is significantly longer than that of house flies (< 5 d). In comparison to house flies, it indicates that a single black soldier fly larva can consume more food waste and produce larger pupae [31]. The average lipid content (dry basis) for BSFL and their pupae is 29%, with a range of 11 to 42% [31]. Animal feed can be made from the leftover debris of BSFL after lipid extraction due to its high protein content (≥ 32%, dry basis). BSFL naturally migrate from the substrate to a clean, high area before reaching the pupa stage [17], thus there is no need for them to go through an extra process of separating from food waste. Self-harvesting, another name for this natural activity, can assist in eliminating a labor-intensive gathering method. The results of this experiment can be an initial reference in making biodiesel based on Maggot BSF oil. So that the presence of biodiesel from Maggot BSF oil can be a new alternative in developing renewable energy in Indonesia.

Conclusions

Earth is currently dealing with three issues at once: food, energy, and water (wastewater). This is known as the waste-food-energy (WFE) nexus. There will be nine billion people on the earth by 2050. Nevertheless, this increase is out of harmony with the replenishment of natural resources in terms of both quantity and quality, given the limited amount of land that is available and the depletion of fossil fuels. Therefore, it is critical to find a solution to this energy issue before it puts additional places in jeopardy in the near future. Hydro, wind, geothermal, and solar energy are examples of alternative renewable energy sources that have been attempted to be obtained. Furthermore, biodiesel is an additional sustainable energy source that has garnered global attention. Researchers have conducted a large number of studies relating to the use of BSFL. Studies on the relative flash times of Maggot BSFL oil, however, have not been done. As a result, the flame times of several other types of oil and Maggot BSFL oil will be compared in this paper. This study shows that the highest flame is a mixture of Maggot BSF oil and Pertamina Dex, which is around 16.31-16.44 minutes. Furthermore, this study also provides information on the significant differences in flame length for each type of oil, such as Maggot BSF oil, used cooking oil, Pertamina Dex and a mixture of Maggot BSF oil and Pertamina Dex. The results of this experiment can be an initial reference in making biodiesel based on Maggot BSF oil. So that the presence of biodiesel from Maggot BSF oil can be a new alternative in developing renewable energy in Indonesia.

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Author Contributions

DR: Conceptualization, method, investigation, writing, editing, supervision, review; NYH: Method investigation, data investigation. VAP: Investigation, editing review; AIR: editing, review

Conflicts of Interest

The authors state that none of the work described in this publication appears to have been influenced by any known competing financial interests or personal ties.

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