BioLink : Jurnal Biologi Lingkungan, Industri dan Kesehatan, Vol. 11 (1) August (2024)
ISSN: 2356- 458X (print) ISSN: 2597-5269 (online)
DOI: 10.31289/biolink.v11i1.12408

BIOLINK
JURNAL BIOLOGI LINGKUNGAN, INDUSTRI, KESEHATAN

Available online http://ojs.uma.ac.id/index.php/biolink

UTILIZATION OF BIOMASS WASTE WITH STEARIC ACID AS FIRE STARTER

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Submitted: 05-07-2024; Reviewed: 17-07-2024; Accepted: 14-08-2024

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Abstract

Fire starter is a product used to ignite a flame, particularly when using firewood, and is considered a potential alternative solution for managing biomass waste in Indonesia. This study aims to determine the quality of fire starters made from sawdust, pine cones, and dry leaves, using stearic acid as an adhesive. The research consists of three stages: production of fire starter, quality testing, and data analysis. The ratios of biomass to stearic acid used in this study are 3:8, 2:7, and 1:6. The quality tests conducted include ignition time, burn duration, burning rate, flame height, and durability test. The results indicate that in the ignition time test, the fire starter made from dry leaves had the fastest ignition time (17 seconds). The burn duration test showed that sawdust was the best material (1,423 seconds). The burning rate test found that dry leaves had the best result (0.035 g/s). The flame height test revealed that sawdust produced the tallest flame (35 cm). For the durability test, all the fire starters had the same durability value (100%).

Keywords*: Pine Cones; Dry Leaves; Fire Starter; Sawdust; Stearic Acid*

How to Cite*:* Juang, D.S., Arifah, D.Z., Alfaroh, B., Rasyad, A.S., & Agustina, A. (2024). Utilization Of Biomass Waste with Stearic Acid as Fire Starter*. BioLink: Jurnal Biologi Lingkungan, Industri, Kesehatan,* Vol.11 (1): 78-89

INTRODUCTION

Biomass is organic material in the form of products or waste that is formed through the photosynthesis process (Wulandari et al., 2019). According to Sayang (2023), biomass is an alternative energy that can be obtained from forestry and agricultural waste which is considered no longer useful, but can actually be used as an alternative fuel energy source. Even though biomass energy is available in large quantities, its utilization has not been carried out optimally. This alternative energy can be produced with simple technology. Increasing the use of biomass energy can help reduce dependence on fossil fuels and reduce greenhouse gas emissions. As an agricultural country, Indonesia has large biomass energy potential. The potential for biomass in Indonesia that can be used as an energy source is very abundant, Indonesia's biomass potential is 146.7 million tons per year (Parinduri & Parinduri, 2020).

Biomass has the potential as solid, liquid or gas fuel using various technologies (Syarif et al., 2023), and to be able to utilize biomass as fuel, it must be processed first by carrying out biomass conversion. There are many forms of utilization of biomass waste, including biobriquettes, gasification, pyrolysis, liquidification, biochemistry, densification and carbonization (Parinduri & Parinduri, 2020).

So far, sawdust still has problems in its management and processing which have a negative impact on the environment (Wulandari, 2019). In general, processing 100 kg of wood using a standard saw machine will produce 12-25 kg of sawdust (Varma et al., 2019). According to Ramadhan & Jelita (2023), dry leaves also have similar problems, where dry leaf waste, which is generally eliminated through burning, will cause problems in the form of air pollution. In fact, dry leaves with a certain biomass value can be processed and utilized optimally as alternative fuel (Hermawan & Aulia, 2021).

Pine cone waste is also not much different from the previous two wastes. Suluh (2017) stated that on average pine trees produce 75 kg of fruit per year. Then, quoting from the official UPT PPK UNS website (2019), the number of pine trees in KHDTK Gunung Bromo is 41,495 trees, so the estimated pine cone waste in KHDTK Gunung Bromo is 3,112,125 kg every year. If we refer to previous research, pine cones have been proved to be used as an efficient alternative fuel (Suluh, 2017), so they are very useful in minimizing the increase in air pollution (Haryati & Amir, 2021).

One form of utilizing biomass energy is through a fire starter. According to Ezéchiel et al. (2023) ecological fire starter is an object for starting a flame made from organic materials which is one way to reduce waste, circular economy and energy problems. Fire starters are mostly used when environmental conditions are unfavorable, such as strong winds and rain when camping or doing outdoor activities, so direct use of lighters is limited. Jailani et al. (2023) also explained that fire starters are considered to be an alternative solution in reducing biomass waste which has been a serious problem in Indonesia.

Several studies have examined fire starters, including Ezéchiel et al., (2023), which investigates the development of environmentally friendly fire starters using sawdust and vegetable oil, and Jailani et al., (2023) which focuses on banana plant stems as a primary ingredient. However, both studies have notable limitations, such as the absence of detailed information on manufacturing procedures and comparisons of composition. Addressing these gaps, the present research aims to provide a comprehensive analysis of the potential use of biomass waste as the primary material for fire starters and to identify which fire starter offers the best quality. This study seeks to enrich the literature on fire starters by addressing the current lack of up-to-date, relevant, and scientific information. Consequently, this research not only contributes to improved waste management but also enhances the understanding of fire starters.

RESEARCH METHOD

Tools and materials

This research was conducted in January 2024 at Universitas Sebelas Maret. The tools used in this research were oven, gas stove, pans, digital scale, spoons, stopwatch, camera, measuring tape, paper molds, matches, tally sheets, mashing tool, blender, knives and containers. The ingredients for making this fire starter include pine cones, dry leaves, sawdust, and wax (stearic acid). Pine cones and dry leaves were obtained from KHDTK Gunung Bromo, Karanganyar, Central Java. Meanwhile, sawdust and wax (stearic acid) are obtained through online marketplace. This research consists of three stages, namely the fire starter manufacturing stage, the fire starter quality testing stage, and the data analysis stage. The stages of making a fire starter and testing it are explained as follows:

Production of Fire Starter

1. Preparation of raw materials

The dry leaves were sorted and washed first then crushed using a blender. Pine cones are cleaned from dirt, sorted and chopped into small sizes using a knife. Sawdust was purchased online and is ready to use

2. Biomass drying

The crushed biomass was then dried using an oven at 120°C for 4 x 10 minutes, every 10 minutes the biomass was stirred to even out the heat and then placed in the oven again for 10 minutes and repeated the same treatment 4 times.

3. Biomass pounding

Dry biomass pounding was carried out using a manual pounding tool. This pounding process is intended so that the materials have more or less the same dimensions so as to avoid bias in weighing and dividing them.

4. Weighing biomass and wax (stearic acid)

Determining the ratio of biomass to stearic acid was based on the results of previous trials (trial & error), in this case the best compositions were found to be 3:8, 2:7, and 1:6. The criteria for determining the best comparison are determined by which composition can produce a fire starter with strong, intact and solid physical properties. The ratio in this research between biomass and wax (stearic acid) is 3:8, 2:7, and 1:6 with the following details:

a) 12 grams of biomass: 32 grams of stearic acid,
b) 8 grams of biomass: 28 grams of stearic acid,
c) 4 grams of biomass: 24 grams of stearic acid.

Weigh all ingredients using a digital scale with an accuracy of 0.01 grams.

5. Mixing fine biomass with wax (stearic acid)

The stages of melting the wax (stearic acid) and mixing it with fine biomass were carried out one by one to minimize the material left behind on the used equipment. After one mixture was finished, all the used equipment was immediately washed to avoid any remaining material left behind which was feared to cause bias. The fire starter that has been made was then left at room temperature for ± 2 hours until it hardened and was ready to be tested as shown in figure 1.

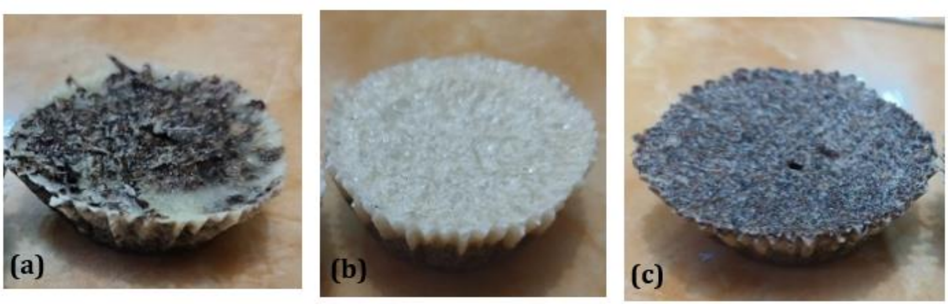

Figure 1. Fire starter after hardening, (a) dry leaves, (b) sawdust, (c) pine cones.

Fire Starter Quality Testing

1. Ignition Time

Quoting Ezéchiel et al. (2023), a test to determine the amount of time for the fire starter to form and maintain the flame is to use a stopwatch with seconds.

2. Burn Duration

Burn duration is an important indicator in determining the quality of the fire starter. Testing this variable is by calculating the time from when the fire starter starts to light until the fire starter goes out by itself. Calculations were carried out using a stopwatch (Ezéchiel et al., 2023).

3. Burning Rate

According to Gazali & Tang (2021) the burning rate or combustion power is the result of a comparison between the mass of the fire starter that burns (g) and the burning time (s).

According to Putri & Andasuryani (2017), the residual content of the fire starter can be calculated using this formula:

$$Combustion\ residue\ level\ (\%) = \frac{m_1}{m_0} \times 100$$

$$Burning\ rate\ (g/s) = \frac{m_0 - m_1}{s}$$

Where:

m0 = mass of fire starter before burning (grams)

m1 = mass of fire starter after burning (grams)

s = duration (seconds)

4. Flame Height

Ezéchiel et al. (2023) stated that flame height is an important factor in determining the quality of the fire starter. Flame height was measured as the distance from the tip of the top surface of the fire starter to the base of the flame that forms. The unit used is centimeters (cm).

5. Durability Test

Quoting research by Kabok et al. (2018) a durability test was carried out by dropping the fire starter from a height of 2 meters until it split into ≥ 1 part. The number of drops and the number of fragments formed are recorded and calculated using the formula:

$$Durability\ (\%) = \frac{Number\ of\ drops}{Number\ of\ fragments} \times 100$$

RESULTS AND DISCUSSION

Residual Content of Fire Starter After Combustion

Based on Rindayatno & Lewar (2017) the burning rate is a comparison between the amount of mass that is burned (grams) and the length of time the fire starter burns (s). Based on research by Mustain et al. (2021), differences in composition have a significant effect on the combustion residue produced. The low level of combustion residue produced by fire starters made from wood dust is thought to be due to the smaller particle size, which causes the stearic acid used to be more integrated and causes fire starters made from sawdust to burn more than the fire starters made from dry leaves and pine cones.

Table 1. Fire starter combustion residue levels after combustion

Combustion residue content (%)			
Composition	**Sawdust**	**Pine cones**	**Dry leaves**
3:8	10.61	16.31	16.61
2:7	6.44	10.33	12.66
1:6	6.53	11.03	12.28

Based on Table 1, fire starters that use sawdust as materials show the lowest levels of combustion residue at composition 2:7, followed by compositions 1:6 and 3:8. For fire starters made from pine cones, the 2:7 composition also produces the lowest levels of combustion residue, followed by the 1:6 and 3:8 compositions. On the other hand, the fire starter that used dry leaves has the highest combustion residue content of the three materials, with the best composition being 1:6, followed by 2:7 and 3:8. The ash content value itself varies depending on the type of biomass material used (Fatriani et al., 2018). The lower the residual content of the fire starter produced, the more combustion occurs perfectly, indicating that the quality of the fire starter is better. Conditions before and after burning are presented in Figure 2.

(a) (b)

Figure 2. (a) Fire starter before burning (from left: dry leaves, sawdust, pine nuts), (b) Fire starter after burning (from left: sawdust, pine nuts, dry leaves)

Fire Starter Quality Analysis

Reprocessing biomass waste in the form of sawdust, pine cones and dry leaves has succeeded in producing products that are useful, of good quality, and have a role in overcoming biomass waste management in Indonesia. Even though there are no standards set for the quality of fire starters, based on a series of tests that have been carried out it shows that the fire starters made have good physical and mechanical properties.

Testing the quality of the fire starter is needed to determine the quality of the fire starter which is expected to be a benchmark for the potential of the fire starter as a processed biomass waste product. The series of tests carried out in this research were the ignition time, the burn duration, the burning rate, the flame height, and the durability test. The results of each test on each fire starterpresented in Figures 3, 4, 5, 6, and 7.

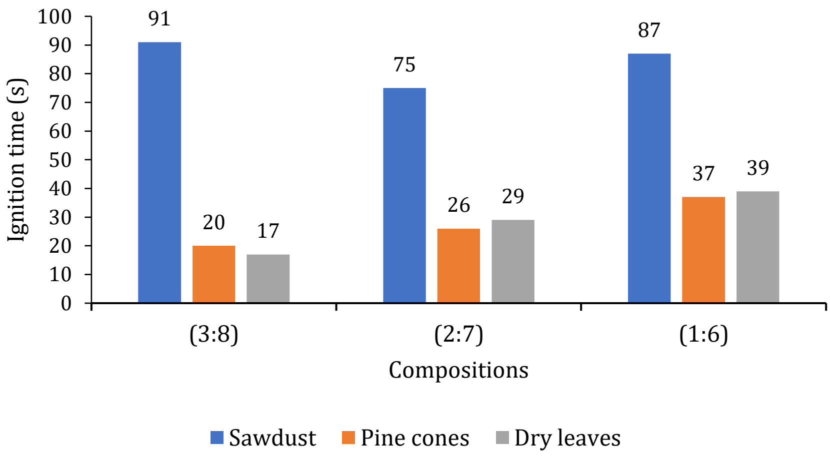

Figure 3. Test result for ignition time (s)

Based on Figure 3, the sawdust fire starter that ignites the fastest is the 2:7 composition, the pine cone material shows the fastest time at the 3:8 composition, and the dry leaf material has the fastest ignition time at the 3:8 ratio as well. Overall, the fire starter with the fastest ignition time is made from dry leaves with a composition of 3:8. According to Ridhuan et al. (2020) fire starters made from dry leaves burn more easily and maintain the flame because their shape is looser and lighter when compared to sawdust and pine cones which have a more compact, dense and solid physique.

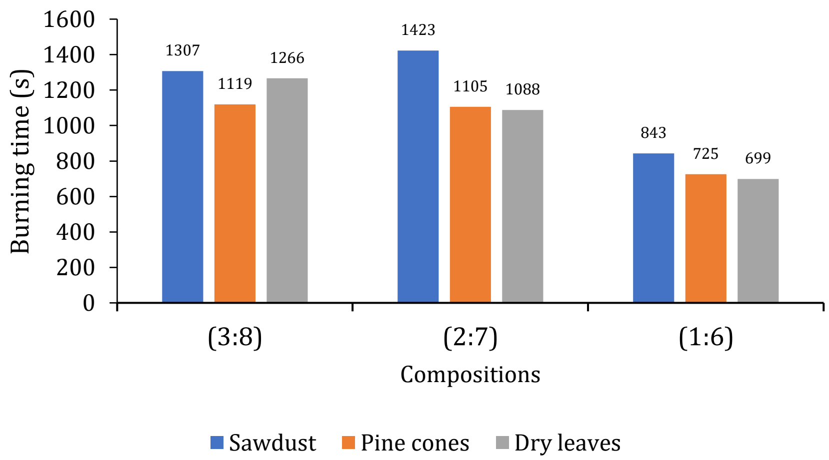

Figure 4. Test results for burning time (s)

The burning time for each material used varies. For sawdust, the best composition is 2:7 which shows 1423 seconds. For pine cones, the composition that showed the longest time was 3:8 with a time of 1119 seconds. And in dry leaves, the best composition is found in a ratio of 3:8 which shows a burning time of 1266 seconds.

The raw material demonstrating the longest burning time is sawdust with a composition of 2:7. This result aligns with research by Kapita et al. (2021), which suggests that the burn duration can be influenced by the biomass composition present in the fire starter. According to Yu et al., (2023), pine cone carbon content reaches 42.62%, while Hazmi (2017) reported that dry leaves contain an average carbon content of 45.9%. In contrast, sawdust has a carbon content ranging from 77.51% to 93.59% (Elehinafe et al., 2019).

Mahendry et al., (2023) assert that fire starters exhibit improved energy as fuel when they contain materials with higher carbon content. This observation is consistent with Figure 4, which illustrates that fire starters made from sawdust, having a higher carbon content, produce the longest flame.

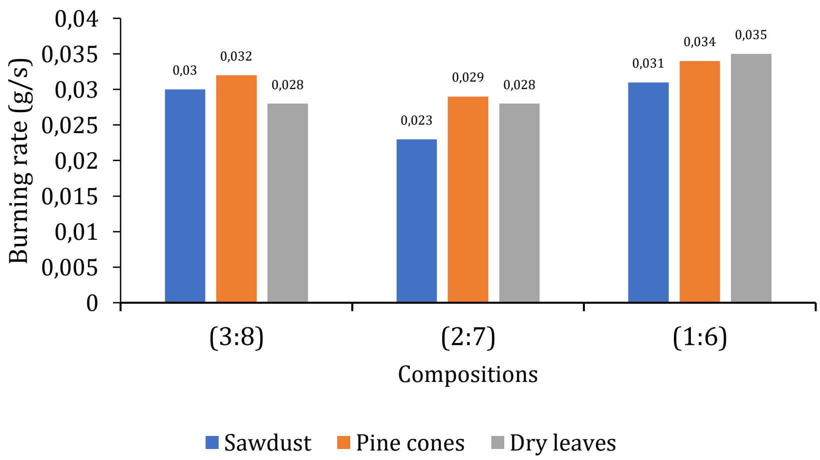

Figure 5. Burning rate test results (g/s)

According to Nasrullah et al. (2023) burning rate generally measures how fast the flame spreads in fire starters substence. The burning rate is influenced by various factors such as temperature, pressure, mixture composition, and physical properties of the fire starter. A high burning rate indicates high combustion efficiency and good heat distribution. Based on the 3 materials that have been tested, the fastest burning rate is shown in the same composition, namely 1:6 for each material. In sawdust it reaches 0.031 g/s, in pine cones it reaches 0.034 g/s, while in dry leaves it reaches 0.035 g/s. Aljarwi et al. (2020) explained that the burning rate is a phenomenon that depends on several factors, starting from the fuel/air ratio to the nature of the fuel mixture. So the higher the adhesive in the fire starter, which also functions as fuel, the higher the burning rate. In other words the faster the fire starter will run out (Pambudi et al., 2018).

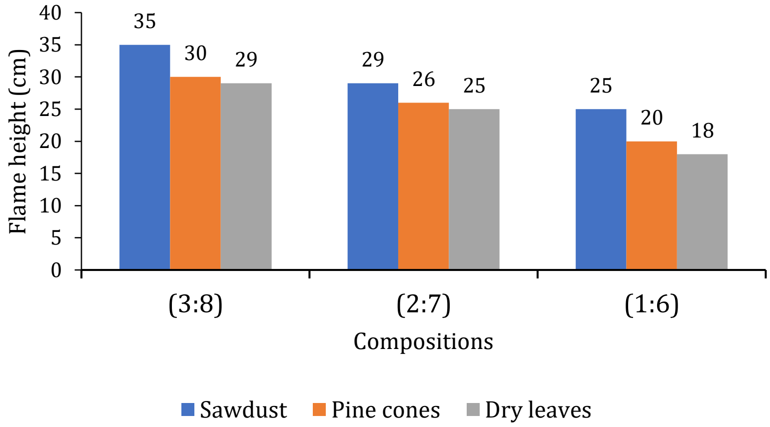

Figure 6. Flame height test results (cm)

Based on the experiments that have been carried out, the flame height of each material and the composition of the fire starter are different. Based on the test results (Figure 6), the highest flame height of the three materials came from the same composition, namely 3:8 composition, with a height of 35 cm for sawdust material, 30 cm for pine cones, and a height of 29 cm for leaf material. dry. This is caused by sawdust which has a smaller particle size, thus providing space for the wax. Based on the research results of Ezéchiel et al. (2023) the more burning substance in this case in the form of wax, the higher the flame. This is because more fuel will make it easier for fire to form. Zhen et al. (2016) stated in their research that the flame height is influenced by the ratio of the fuel and air mixture.

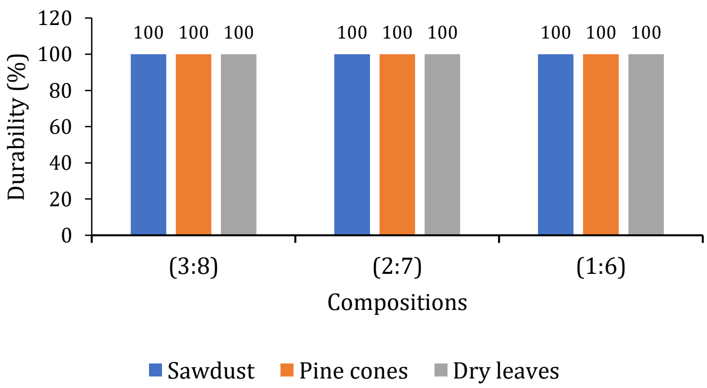

Figure 7. Durability test results (%)

The durability of the fire starter is tested using the drop test method. The drop test itself is a method carried out by dropping the fire starter from a height of 2 meters until it breaks into ≥1 part and the resistance value is calculated by comparing the number of drops with the number of fragments that arise (Ezéchiel et al., 2023).

The rupture of fire starter particles is influenced by several factors, including the orientation of the fire starter upon impact with the ground. Specifically, if the fire starter initially lands on its more fragile areas, the likelihood of particle release increases compared to if the more robust central portion makes contact first. Despite this, testing of each fire starter, conducted 10 times, yielded no breakage. According to the provided formula, all tested fire starters demonstrated 100% resistance (see Figure 7). This result can be attributed to the fact that the more durable part of the fire starter typically impacts the ground first.

Virgiwan (2022) notes that greater resistance in fire starters correlates with higher density values and, consequently, greater calorific value. The purpose of the drop test is to assess the fire starter's resistance to impacts with hard surfaces, which is crucial for its performance in packaging, distribution, and storing. Additionally, Kale et al., (2019) suggest that incorporating stearic acid can enhance the mechanical properties of fire starters. This is supported by Pranindyah (2016), who found that increased concentrations of stearic acid improve both mechanical and hydrophobic properties.

CONCLUSION

From the results of study that has been carried out to utilize biomass waste and stearic acid as materials for making fire starters, it indicates that in testing the best ignition time is one made from dry leaves with a composition of 3:8 for 17 seconds. Meanwhile, in the burn duration test, the best fire starter was made from sawdust with a composition of 2:7 for 1,423 seconds. In the burning rate test, the best fire starter was dry leaves with a composition of 1:6, the results showed a value of 0.035 g/s. The best flame height test results are dry leaves with a composition of 3:8, the results of which show a value of 35 cm. Furthermore, the final test, namely the durability test with a drop test, showed that all fire starters had the same quality.

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