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THE MANUFACTURING CONDITIONS OF LIQUID ORGANIC FERTILIZERS THROUGH THE FERMENTATION OF BAMBOO SHOOTS (*DENDROCALAMUS ASPER*) AS THE BASIS FOR THE CONTEXTUAL CHEMISTRY TEACHING MATERIALS IN REACTION RATE

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Abstract

The difficulties faced by students in studying chemistry, one of which is the rate of reaction, is one of the reasons why this research was conducted. This review can serve as a starting point for research related to other materials This research aims to compile worksheet-shaped teaching materials on reaction rate materials with the context of manufacturing liquid organic fertilizers (LOF) through the fermentation of bamboo shoots (*Dendrocalamus Asper*). In principle, this research is carried out with steps (1) optimization of the conditions for manufacturing liquid organic fertilizers as the foundation for the creation of teaching materials, and worksheets and (2) the creation of teaching materials in the form of a worksheet. Based on the results of this study, student worksheets have been prepared for the practical implementation of the reaction order determination experiment. The results of the study show: (1) The optimum parameter in the preparation of the reaction rate practicum procedure is, a good type of bamboo shoots, namely betung bamboo shoots using 100 mL of EM4 and a mass of 200 g of betung bamboo shoots. The influence of the surface area of the reactions touch can also be carried out through this experiment, namely using bamboo shoots cut into small pieces and mashed bamboo shoots. (2) Characteristics of teaching materials in the form of worksheets developed are very following the following criteria: curriculum, and scientific correctness. The readability test showed that the majority of these teaching materials were easy for students to read with a readability percentage of 75.21% the easily categorized text of 91% and difficult by 9%.

Keywords: 4STMD, Contextual teaching materials, *Dendrocalamus Asper*, Liquid organic fertilizer, Project based learning, Rate of reaction.

1. Introduction

The fact that students still struggle with learning Chemistry is one of the problems of the quality of education, especially about this topic. Most chemistry concepts are sequential, abstract, and can change quickly, causing students to have difficulty understanding the subject [1]. To overcome the difficulties students face when learning chemistry, a learning approach is needed that can make lessons fun and not difficult. Context-based learning is one of the methods advocated by specialists that have been shown to increase students' comprehension of chemical concepts and scientific literacy [2]. Context-based learning is closely related to the environment and culture around us. Students' cultural and environmental background has a greater influence on the educational process than the influence of learning materials [3].

According to certain studies, students have misconceptions of how reaction rates fluctuate over time, which include the following misconceptions: temperature's impact on a reaction's rate; A mathematical link between the rate of reaction and the number of moles, as well as the impact of adding catalysts on activation energy [4]. This issue is caused by the rate of reaction phenomenon is abstract and difficult to observe. It makes conveying the concept and implementing it difficult. The possible factor influencing the difficulty mentioned is the teaching materials used. Teaching materials that link theory with its application make it easier for students to understand concepts, by demonstrating macroscopically, microscopically, and symbolically [5, 6]. However, most students still view the rate of reaction material in chemistry classes, in particular, as being challenging [7].

The study of chemical process rates is known as chemical kinetics, sometimes known as reaction kinetics or reaction rate. It includes research into how various experimental setups can affect a chemical reaction's rate and reveal information about the mechanism and transition states of the reaction, as well as the creation of mathematical models that can depict the properties of a chemical reaction [8, 9]. The processing of bamboo shoots into liquid fertilizer involves various chemical processes and in it, there are essential concepts that can be learned by students. The rate at which chemical reactions take place varies substantially. While some may take days, months, or even years to attain balance, some are essentially instantaneous. The amount of time it takes for a given chemical reaction to change either the amount or concentration of the reactants or the products is known as the reaction rate. Measuring the rate of change in reactant or product concentrations is necessary for the experimental calculation of reaction rates.

The production of LOF from bamboo shoots (*Dendrocalamus asper*) through a fermentation process with the assistance of bacteria is one situation that can be used as a focus in chemical education [8]. By measuring changes in the volume of gas produced at any time, this fermentation process may be monitored. As a result, the topic of fermentation can be highly intriguing when learning about reaction rate information. The choice of the reaction's order is one of the subtopics of reaction rate. In this study, students can use a project-based learning approach to experiment to discover the order of the reaction, which involves fermenting bamboo shoots into LOF.

Teaching materials are an important part of the learning process, and their quality must be taken seriously. For teachers, teaching materials function as guidelines in the learning process and as competency material that students must learn, and for students, teaching materials function as a tool to assess learning achievement. For students, teaching materials function as a guide in the learning process and are a substance of competence that should be studied and as an evaluation tool for learning achievement [9]. The creation of teaching materials should concentrate on a number of elements, including providing examples or illustrations that correspond to the intended learning materials; providing practice questions or tasks as feedback for students to measure mastery of contextual; using straightforward language to make it easier for students to comprehend the subject matter on their own. These elements are all important for enabling students to learn independently and master the learning process [9]. One of the teaching materials that are often used by teachers is student worksheets for practicum. The development of this student worksheet becomes very important when learning is carried out using Project-based Learning.

Therefore, the authors do the development of teaching materials based on the results of studies in contexts that are often encountered in everyday life. The concept of reaction rate has a lot to do with everyday life and is very important to apply. One context related to the reaction rate is the fabric of LOF from bamboo shoots (*Dendrocalamus Asper*) through a fermentation process with the help of bacteria [8]. Using the fermentation context, students' worksheets are arranged as part of the teaching materials in reaction rate learning with project-based learning models. Therefore this novelty can solve problems in the learning of chemistry at the reaction rate material.

2. Theoretical Framework

The contextual learning strategy promotes students' linkages between knowledge and its applications to their lives as family members, citizens, and workers by assisting teachers in connecting subject matter content to real-world circumstances. The idea of "contextual teaching and learning" emphasizes the complete student's activities, including their mental and physical health [2]. This idea holds that learning is a process that occurs naturally in life and is not just a matter of retaining information, thinking about it, or practicing repetitions. Additionally, this idea is a learning notion that aids instructors in connecting a subject under study and applying it to all facets of life. For learning to be meaningful, students gradually gain knowledge and abilities from a constrained context through the process of self-construction. Many educators in the arts and humanities have used contextual learning to achieve meaningful learning, but scientific teachers need to use it most to improve learning in the sciences [10]. Contextual learning motivates learners to take charge of their learning and to relate knowledge and its application to the various contexts of their lives [11]. It has a characteristic of relating, experiencing, applying, cooperating, and transferring knowledge learned. [2].

In the learning process, teaching materials are a very important part. Teaching materials are a set of subject matter that refers to the curriculum used to achieve competency standards and basic competencies that have been defined [9]. Competency-based teaching materials, according to the National Center, are all types of resources used to help teachers or instructors carry out the learning process in the classroom [5]. Contextual teaching materials are a set of materials that are arranged in a coherent and structured manner that can describe the competencies to be achieved by students [12]. These materials are structured by connecting real-world situations and can improve students' ability to relate knowledge to its application in everyday life.

With the many benefits of the contextual learning approach, we have developed teaching materials in the form of student worksheets on learning the rate of reaction in the context of making LOF through bamboo shoot fermentation. These fertilizers are commonly used by certain communities, in this case, traditional farmers in Indonesia to deal with fertility problems and eradicate pests on their plants. Bamboo shoots (*Dendrocalamus Asper*) or bamboo itself is widely known among the public because bamboo is a plant that cannot be separated from people's lives. Bamboo trees have long been used as house-building materials. Even some types of young bamboo are used to be a source of food to complement various food menus [13]. Some self-taught farmers have used bamboo shoots as organic fertilizer in the fertility of other crops.

Bamboo shoots are young bamboo that grows at the base of bamboo groves [8]. Bamboo shoots are still sheathed by reed fronds until the bamboo reaches a certain height. In certain types of bamboo, the red leaf will be released. The morphology of shoots is cone-shaped and brown. Bamboo shoots or young shoots of this plant in addition to being healthy for human consumption, it is also beneficial for other plants if processed into LOF. The LOF of bamboo shoots has a very high content of organic compounds and gibberellin is so high that it can stimulate plant growth [14].

In addition, the LOF of bamboo shoots also contains organisms that are important to help plant growth, namely *Azotobacter*, and *Azospirillum* [15]. When viewed from the content, bamboo shoots LOF can be used as a growth stimulant in the vegetative phase. This is because in general every 100 g of bamboo shoots contains water nutrients (85.63%), protein (2.5%), fat (0.2%), glucose (2%), stearate (9.1%) phosphorus (0.05%), calcium (0.028%), potassium (0.553%), vitamin A, vitamin B1, vitamin B2, and vitamin C. The POC of bamboo shoots contained an N-total of 0.72%, P_2O_5 of 0.04%, and K_2O of 0.12% [15]. The use of LOF in several trials shows that LOF is effective for vegetable crops [16-18].

The fermentation process always involves microorganisms that play an important role in starting fermentation [19]. The activity of microorganisms involved in fermentation depends on intrinsic factor and extrinsic. Intrinsic factors needed for the growth of microorganisms, in general, are acidity or wetness (pH), temperature, moisture content, nutrient content, and other conditions [20]. Some microorganisms grow at pH values between 6.6-7.5 and some grow at a pH below 4.0. Anaerobic fermentation reactions can be written as follows [21].

$$\text{Step 1: } (\text{C6H12O6})_n \xrightarrow{\text{hydrolysis}} \text{n(C6H12O6)}$$

$$\text{Step 2: } (\text{C6H12O6})_{\text{aq}} + \text{microorganisms (EM4)} \rightarrow 2(\text{C2H5OH})_{(\text{aq})} + 2\text{CO2}_{(\text{g})} + \text{kalor}$$

In this case, microorganisms that help the fermentation process are contained in an Effective Microorganism 4 (EM4) solution. EM4 is a liquid containing a mixture of several living microorganisms that is useful for decomposition and soil nutrient supply. EM4 solution contains a combination of photosynthetic bacteria (*Rhodopseudomonas spp*.), lactic acid bacteria (*Lactobacillus spp*.), and yeast (*Saccharomyces spp*.). The rate of fermentation can be followed by measuring the volume of oxidized carbon gas produced [22].

3. Method

3.1. Optimization

Optimization aims to determine the best conditions (easy to observe) in the experimental implementation of making LOF from bamboo shoots. The conditions referred to are experimental parameters, namely the concentration of EM4 solution and bamboo shoots, types of shoots, and surface area of bamboo shoots used. Observations were made to determine the volume of gas produced in the fermentation of bamboo shoots into LOF. At the optimum experimental parameters produced gas with an easily observable volume. The observed gas volume is said to be good if the volume of gas produced is neither too small nor too large. In this study, because a simple instrument was used, the observed gas volume was in the range of 10 mL to a maximum of 4000 mL. Besides that, time is a good observation, the time when gas starts to form, and the end of fermentation is an important variable to state that the experiment of fermenting bamboo shoots into LOF can be carried out by students. Gas formation during the fermentation process can be measured over a certain period (Fig. 1). Changes in gas volume over a certain period can be discussed as one of the chemical materials in high school, namely the rate of reaction. Therefore, the results of the optimization carried out will be the basis for the preparation of experimental procedures for factors that affect the reaction rate in the worksheet to be developed.

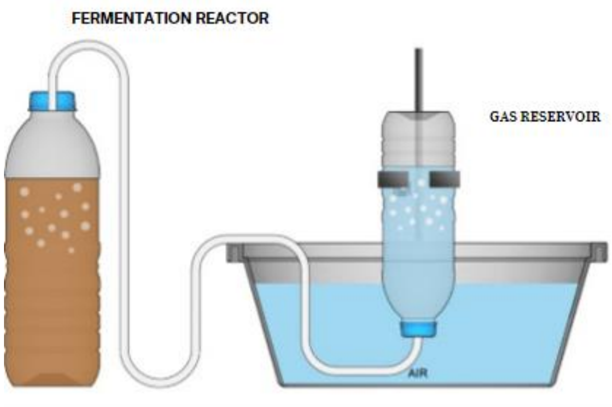

Fig. 1. Installation of volume measurement of fermented gas [7].

In determining the gas formed during the fermentation process, it can be used as a reference in the occurrence of a glucose decomposition reaction, because if the CO_2 gas is no longer formed, the carbohydrates in the bamboo shoots have been exhausted and there is no process of breaking down glucose molecules again by the microorganisms in the bamboo shoots. EM4. Gas formation during the fermentation process can be measured over a certain period. Changes in gas volume over a certain period can be discussed as one of the chemicals in high school, namely the reaction rate.

3.2. Preparation of worksheet

The prepared worksheet presents what students should do, namely doing, observing, and analysing. For this purpose, various studies are carried out, namely reviewing the latest curriculum, the Special Conditions Curriculum, and learning models that will be applied. Curriculum analysis is carried out to determine the basic competencies (KD) that correspond to the reaction rate. The subject matter that developed on teaching materials was a development of KD 3.6 and KD 3.7. The indicators of this KD include the concept of how concentration, pressure, and temperature may affect the rate of a reaction, why for surface reactions, the surface area is a key factor, and how to determine the order of the reaction from experiment data. In this study, the chosen learning model is project-based learning.

To prepare the worksheet designed the initial frame of reference and compiled a prototype of the worksheet. This activity is cyclical (related to the cycle) and divided into three forms, namely design, feasibility test, and revision. At this step also prepared research instruments in the form of content feasibility test sheets and construct feasibility test sheets tested on 20 high school students of class XI.

4. Results and Discussion

4.1. Optimisation

4.1.1. Effect of bamboo shoots varieties

In the experiments that have been performed, it was found that in fermentation, Betung bamboo shoots produced more gas volume than rope bamboo shoots at the same time. Based on Fig. 2, information is obtained that the type of bamboo shoots affects the rate of the fermentation reaction. This is due to the different types of substances and types of bonds present in bamboo because in its use, bamboo shoots are commonly used as building materials and have an intermolecular density of 0.78 g/cm^3. While the type of bamboo rope has a density of 0.93 g/cm^3. This causes the microorganisms in EM4 to more easily break down glucose into carbon dioxide gas in the fermentation process of bamboo shoots than string shoots. Thus, more gas will be formed, and the reaction will take place faster from bamboo shoots than from rope shoots.

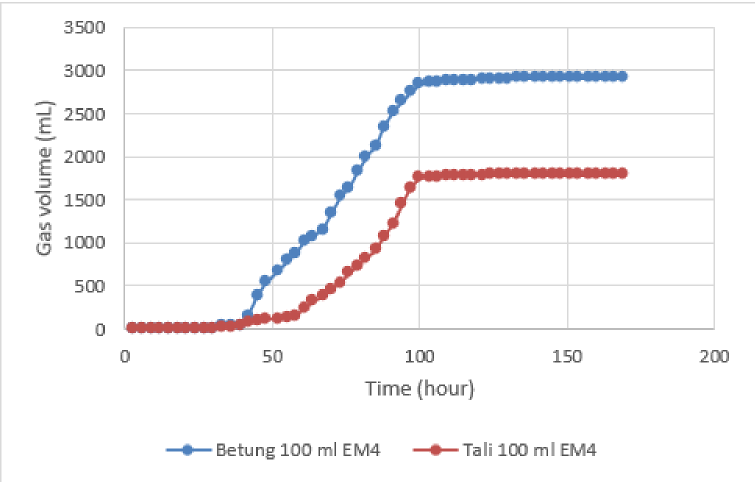

Fig. 2. Gas volume produced for different types of bamboo shoots (mass 100 g) with EM4 100 mL.

According to the results of the experiments, EM4 solution with volumes of 100, 80, or 70 mL can be used in the preparation of experimental procedures for the effect of bamboo shoots on the rate of fermentation in LKS with the same mass of bamboo shoots.

4.1.2. Effect of concentration

In this experiment, optimization was done to ascertain the impact of the concentration of EM4, and bamboo shoots used. From several experiments that have been carried out, good observations with data can show differences in reaction rates for each concentration of bamboo shoots with the same volume of EM4 solution and concentrations of EM4 solutions with the same mass of bamboo shoots in the experiment. Based on the gas produced during fermentation, the effect of bamboo shoot concentration and EM4 solution on the fermentation reaction rate was obtained as shown in Figs. 3 and 4.

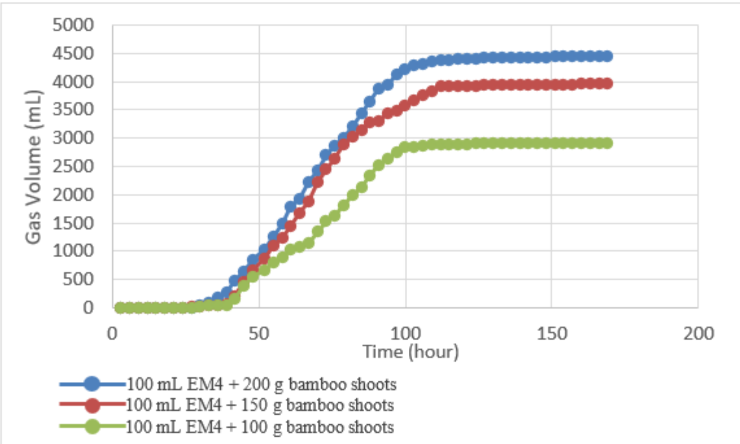

Fig. 3. The volume of gas produced for different masses of bamboo shoots with the same volume of EM4 solution.

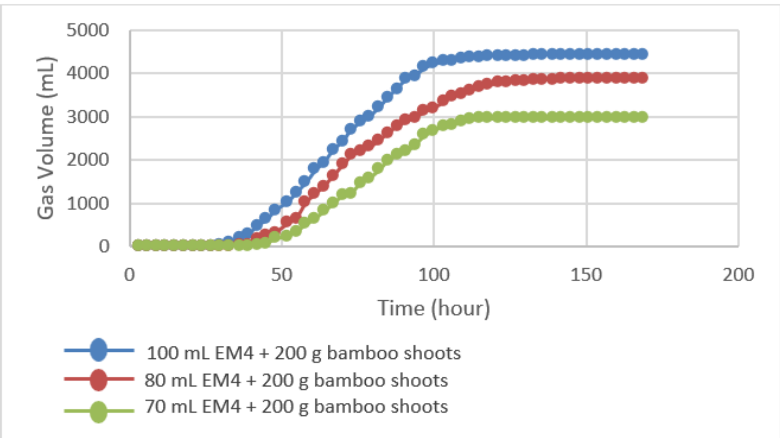

Fig. 4. Gas volume produced for different volumes of EM4 solution with the same mass of betung bamboo shoots.

Based on the experiments that have been carried out, the preparation of experimental procedures for the effect of concentration can be carried out on both bamboo shoots and EM4 solution. In the experimental procedure outlined in the worksheet, the variations in the mass of bamboo shoots used were 100, 150, and 200 g at the same EM4 volume of 100 mL. Meanwhile, for the experiment on the effect of EM4 concentration, volume variations of 70, 80, and 100 mL were used at the same mass of bamboo shoots, namely 200 g.

4.1.3. Effect of Surface Area

In this experiment, the surface area was varied into two, namely bamboo shoots that were blended until smooth and thinly sliced bamboo shoots, with the volume of EM4 and other ingredients kept constant or the same. In this case, the rate of reaction is influenced by the size of the particles of the substance. The wider the surface area of the reacting substance, the easier it is for effective collisions to occur which causes chemical reactions to occur, thereby accelerating the rate of reaction. The surface area of the contact area can be done by reducing the size of the substance. The following in Fig. 5 is the effect of surface area.

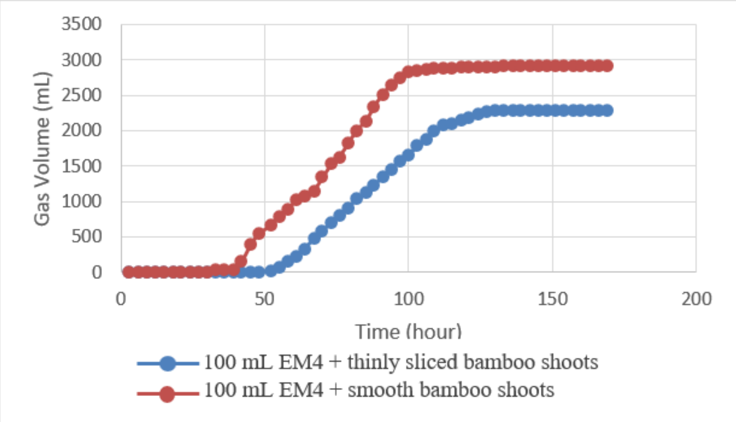

Fig. 5. The effect of the surface area of thinly sliced betung bamboo shoots with smooth betung bamboo shoots with a volume of EM4 100 mL.

From the several experiments that have been carried out, it turns out that the experiment on the impact of surface area on the rate of fermentation has better observations (the experimental results are easy to observe, and the curve is better) for bamboo shoots that are mashed with a volume of 100 and 80 mL of EM4 solution. Therefore, in the LKS experiment on the effect of surface area, 100 and 80 mL of EM4 solution can be used.

4.2. Preparation of teaching materials (Worksheet)

In the process of preparing the worksheet, first a study of the components needed. The step of making the initial design of the Worksheet required an analysis of the needs and context of the worksheet [23].

As explained earlier, the preparation of the worksheet is carried out concerning KD 3.6 and KD 3.7 listed in the curriculum.

3.6 Explain the factors that affect the rate of a reaction using collision theory
3.7 Determine the reaction order and reaction rate constant based on experimental data

The first step of the selection step obtained that KD 3.6 will be developed in teaching materials because the KD contains the main concept of rate of reaction while KD 3.7 contain determine the reaction order and reaction rate constant based on experimental data. After analysing the curriculum, the next step was the development of indicators. The indicators of this KD include the concept of how concentration, pressure, and temperature may affect the rate of a reaction, why for surface reactions, the surface area is an important factor, and how to determine the order of the reaction from experiment data. Indicators that are suitable for reaction rate experiments with the context of making LOF through bamboo shoot fermentation are the influence of the type of material used, the effect of concentration, and the influence of the surface area. The preparation of LKS is also based on the chosen learning model, namely project-based learning. It served as a benchmark for KD's success and a direction for the creation of instructional material. The development of indicators obtained are listed in Table 1.

Table 1. Development of reaction rate indicators.

KD	Indicator	Concept Label
3.6 Explain the factors that affect the rate of a reaction using collision theory	Explain how concentration, pressure, and temperature may affect the rate of a reaction. Explain why, for surface reactions, the surface area is an important factor	Rate of reaction Substance characteristic Concentration Surface area
3.7 Determine the reaction order and reaction rate constant based on experimental data	Explain how to determine the order of the reaction from experiment data.	Reaction order

Table 1 shows that 2 indicators developed in the rate of reactions to the subject matter. Based on the basic competencies and indicators of competency achievement presented in Table 1, after learning the material on the reaction rate, students are expected to be able to explain the factors that influence the reaction rate using collision theory. In addition, after studying this material, students must demonstrate the achievement of learning outcomes related to students' ability to determine the order of reactions based on experimental data. In studying the reaction rate material, students are invited to study the reaction rate in the context of bamboo shoots fermentation in the manufacture of LOF. Then the compilation of the matter was made in the draft of the teaching material (worksheet). Worksheet is important to understand student comprehension [24, 25].

A knowledgeable lecturer in the field of chemical education evaluates the teaching material's draft to determine its viability. The resultant worksheet views are shown in Figs. 6-9.

FERMENTED BAMBOO SHOOTS ORGANIC FERTILIZER EXPERIMENT

Fig. 6. List view of worksheet contents.

5.1. LEARNING PURPOSES

5.1.1. Explain the effect of the characteristic, surface area, and concentration of bamboo shoots on the rate of fermentation of liquid organic fertilizer from bamboo shoots.

5.1.2. Determine the reaction order in the experiment of liquid organic fertilizer from bamboo shoots.

5.2. EXPERIMENT TOOLS

No.	Tools	Size	Amounts
1.	Bottle	1,5 Liter	6
2.	Stick	-	1
3.	Knife	-	1
4.	Transparent Hose (1 m)	diameter : -+0.5 cm	6
5.	Glue gun	-	sufficiently
6.	Scales	1 kg	1
7.	Measuring Cup	100 ml	3
8.	Measuring Cup	250 ml	6
9.	Plastic Water Tub	-	2
10.	Beaker	1 Liter	1
11.	Beaker	500 ml	1
12.	Juice Blender / Food Processor	-	1

5.3. Bamboo Shoots Ingredients

No.	Ingredients	Amounts
1.	Bamboo Shoots	2,5 kg
2.	Palm Sugar	sufficiently
3.	EM4 solution	sufficiently
4.	Rice water	sufficiently
5.	Water	sufficiently

Gambar 6.1. Experiment Tools Set
(Source : author documentation)

Gambar 6.2. Experiment Tools
(Source : author documentation)

Fig. 7. Display of tools and materials about making liquid organic fertilizer through fermentation of bamboo shoots (Dendrocalamus Asper) contained in the worksheet: Materials

Fig. 8. Display of the work procedure for making liquid organic fertilizer through fermentation of bamboo shoots (*Dendrocalamus Asper*) contained in the worksheet: Procedure (Step 1).

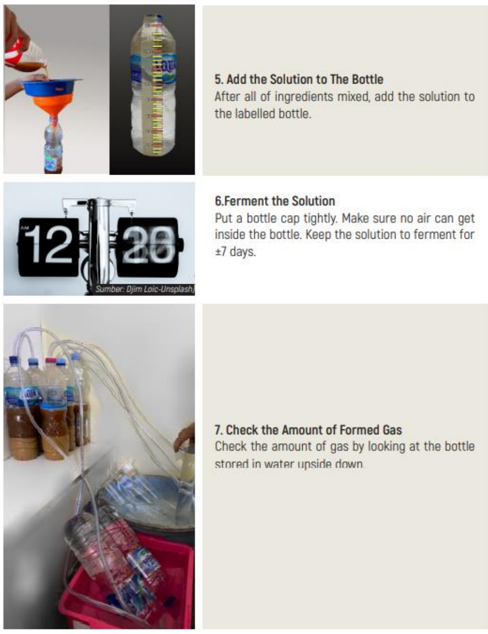

Fig. 9. Display of the work procedure for making liquid organic fertilizer through fermentation of bamboo shoots (*Dendrocalamus Asper*) contained in the worksheet: Procedure (Step 2)

5. Conclusion

The following conclusion can be drawn from the research and discussion's findings:

- Optimization of Fermentation. The optimum parameter in the preparation of the reaction rate practicum procedure is, a good type of bamboo shoots, namely betung bamboo shoots using 100 mL EM4 and a mass of 200 g of betung bamboo shoots. The influence of the surface area of the reactions touch can also be carried out through this experiment, namely using bamboo shoots that are cut into small pieces and bamboo shoots that are mashed.
- Characteristics of teaching materials. Based on the results of the optimization of the manufacturing of LOF from bamboo shoots (*Dendrocalamus Asper*) through a fermentation process with the help of bacteria in this study, student worksheets have been prepared for practical implementation. The subject matter that developed on teaching materials was a development of KD 3.6 and KD 3.7. The indicators of this KD include the concept of how concentration, pressure, and temperature may affect the rate of a reaction, why for surface reactions, the surface area is an important factor, and how to determine the order of the reaction from experiment data. The readability test showed that most of these teaching materials were easy for students to read with a readability percentage of 75.21% with easily categorized text of 91% and difficult by 9%.

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