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Performance Optimalization and Techno-Economic Analysis Liquid Smoke Pyrolysator of *Kesambi* Leaves with LPG Fuel

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Abstract*—Research have been conducted to test the performance and techno-economic analysis of liquid smoke pyrolisator with LPG fuel. Liquid smoke beginning to develop by researchers, to get the higher quality in order to become safe for consumption by the public and not contains carcinogenic substance. Raw material liquid smoke which is used as an alternative material of food preservatives is from *Kesambi* leaves. Kupang State Polytechnic with its innovation namely liquid smoke technology which is used as an alternative ingredient for food preservatives and food additives for flavoring smoke originating from *Kesambi* leaves This research aims to test the performance of liquid smoke producing equipment, conduct techno-economic analysis and study the quality of liquid smoke produced. The research method is the stage of preparation and assembly of tools, preparation of raw materials, the production process of *Kesambi* leaf liquid smoke, the purification of *Kesambi* leaf liquid smoke, quality control testing, performance analysis of the tools concerning yield, capacity and efficient work of the tool, and the techno-economic analysis of liquid smoke pyrolysis *Kesambi* leaf and liquid smoke quality test using a mass spectrometry gas chromatography tool. The result showed that the yield of *Kesambi* leaves liquid smoke was 31,7%. Charcoal of *Kesambi* leaves 33% and 50% while from the corn cob was 16.7% and 33.3%. Charcoal weight is 13.53 kg and the tar weight is 0.092 kg. The yield after the distillation process is 95%. Furthermore, the yield produced from the filtration process is 98.5%. Can be said that, after the filtering process with eolite and activated charcoal filtration media, the liquid smoke of the *Kesambi* leaves becomes pure. From GC / MS analysis, grade 3 and grade 1 *Kesambi* leaf liquid smoke content of acid compounds was 12.63% and 9.57%, phenol compound levels were 3.21% and 2.57%, carbonyl content was 14.13 % and 10.07%. Meanwhile, the level of benzo (a) pyrene at grade 3 was 6.13 µg / kg and was not detected. Liquid smoke *Kesambi* leaves grade 3 still contains benzo (a) pyrene which is very harmful for human health. The value of pH pada asap cair *Kesambi* grade 3 dan 1 was 2.25 and 2.17. The results of economic analysis of the operation of pyrolisis obtained basic costs for producing smoke liquid *Kesambi* leaves was Rp. 1.317/kg. BEP (breakeven point) 118,158 kg / year. Low production costs and BEP value from liquid smoke of *Kesambi* leaves with LPG fuel stated that the liquid smoke of the *Kesambi* leaves is feasible to produce.

Keywords—Kesambi leaves, liquid smoke, tool performance, capacity, economic analysis

I. INTRODUCTION

In general, fresh food is easily damaged, due to the activity of microorganisms and oxidation reactions, therefore preservation steps are needed. At present what is often troubling the public is the large use of formaldehyde compounds as food preservatives that can endanger health.

Basically there are many ways on preserve food, one of which is through fumigation, which has long been used by some people in Indonesia to preserve food. The fumigation process can be carried out through contact with aerosols in the smoking cabinet (traditional method), modern fumigation with liquid smoke. Preservation with liquid smoke is more friendly to the environment, because it does not cause air pollution. Liquid smoke is very adaptive and can be produced commercially. However, we cannot be denied that the use of liquid smoke as a preservative is not yet popular in the sense that it is not well known by ordinary people, only now it has begun to be developed as a substitute for formalin compounds. [1].

Government programs in providing solutions to people who feel disadvantaged in terms of health, then there is a liquid smoke technology that turned out to be used as an alternative preservative that is safe for use by the community. Liquid smoke contains a lot of organic acid compounds that can inhibit the development of microbes such as phenols, acetic acid, and carbonyl, otherwise it will not pollute the environment because the material used is derived from biomass [2].

Research on liquid smoke has begun to develop due to complaints from the public about borax and formalin which are sold freely to be used as food preservatives so the

researchers are developing research on food preservation that is safe to use by food vendors.

Quality liquid smoke can be produced from optimal pyrolysis performance, so it is necessary to test the performance of liquid smoke pyrolysis engineering. Liquid smoke is produced from the pyrolysis process which is carried out combustion in the reactor at high temperatures in a tightly closed room without air intake. The technology of making liquid smoke through the pyrolysis process will produce three kinds of products after passing through the condenser namely heavy fraction, light fraction, and solid fraction.

State Polytechnic of Kupang has developed the liquid smoke of the *Kesambi* leaf as a fumigation material for fish which is locally called se'i fish. Liquid smoke *Kesambi* leaves is expected to replace traditional fumigation which has been handed down as a process of making se'i [3].

Pyrolysis consists of a pyrolysis reactor vessel, condenser pipes, tar capture cyclones, tar reservoirs, condensers, and liquid smoke reservoirs. In this research, to test the performance of liquid smoke pyrolysis tool, the parameters used include the yield of liquid smoke, the processing time, and the quality of liquid smoke testing with a mass spectrometry (GC / MS) gas chromatography and liquid spectrometric gas chromatography (LC / MS). Whereas for the techno-economic analysis the cost of operating equipment is calculated by calculating the fixed costs and non-operating costs of the equipment [4].

II. Related Work

The study of liquid smoke has been carried out by several researchers. Research that has been done using raw materials derived from agricultural waste such as: coconut shell, rice husk, corn cobs and coconut fiber which have not been utilized optimally.

Liquid smoke from *Kesambi* wood has also been reviewed [5] with the immediate results of liquid *Kesambi* wood resulting from 400ºC pyrolysis in making sei meat with liquid smoke of 10%, 20% and 30% different results, both in terms of chemical, physical and properties sensory seiproduced.

Harnowo [6] in her research stated that the highest capacity of tools with coconut shell raw materials was 1.0838 kg / hour while corn cobs were 0.9091 kg / hour. The yield obtained is 31.85% coconut shell and 33% corn cobs.

Liquid smoke research has also been carried out [7] with a condenser of 1.2 m length and 8 hours pyrolysis time obtained the performance of liquid smoke tools with raw materials of teak sawdust sabrang of 6.89 g / (hour.m) and the yield of liquid smoke was 38.0%; charcoal 32.0% while lost components 30.0%. Chess and Lagiyono [2] States that the pyrolysis performanceis 1.25kg / hour.

The studies that have been carried out are limited to the results of liquid smoke and fumigation applications without further development. The obstacle in the field which is mostly faced is less than optimal in production because the pyrolysator is less representative. Thus in this study an in-depth and continuous assessment will include 1) optimizingthe performance of pyrolysis with LPG fuel; 2) pyrolysis techno economic analysis with LPG raw materials; 3) the characteristics of the liquid smoke produced.

Liquid smoke *Kesambi* leaves used in this study has been tested on the actual conditions and environment, the test results prove technically feasible (engineering feasibility).

III. Methods

In this section we describe step by step how to do the research and materials used include leaves and wood *Kesambi* and fuel in the pyrolysis process with LPG. The proposed pyrolysis circuit as shown in the following Figure 1:

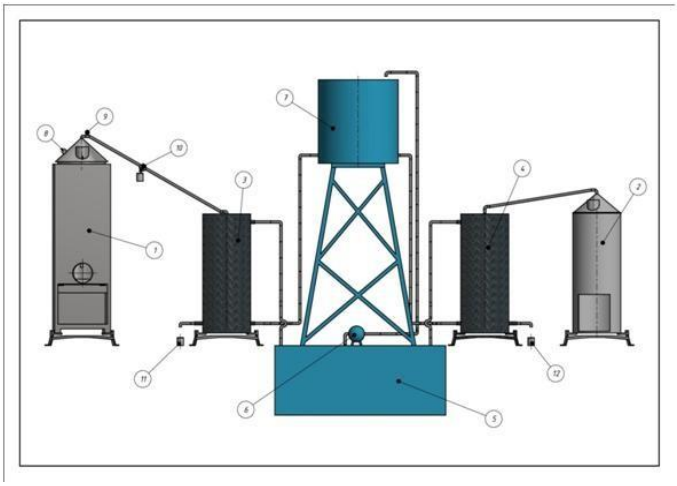

Fig. 1. Pyrolisator.

A. *Preprocessing*

Liquid smoke producing equipment (pyrolysis) hasseparate components or parts, so that to be used thecomponents must be assembled appropriately. The components of liquid smoke pyrolysis include pyrolysis tubes, pipes smoke distributor, tar catcher, condenser, coil pipe, discharge pipe, receptacle liquid smoke, water supply drums, thermometers and furnaces. Component tool these must be precisely strung so that no leakage occurs at the time arson and implementation of activities can go well. A series of liquidsmoke pyrolysis can be seen in Figure 1 above.

B. *Raw Material Conditions*

The raw material used is the *Kesambi* leaves containing cellulose, hemicellulose and lignin, Composition and the moisture content of raw materials will greatly affect the nature of liquid smoke and compounds result. Expected compounds are phenols, acetic acid and compounds carbonyl as well as removing PAH. If the moisture content of ingredients is high,

then the costs are needed in producing liquid smoke will be higher.

Kesambi leaf moisture content between 8-10%, to reduce the water content of the *Kesambi* leaves, drying is done. aired in the room.

C. *Kesambi Leaf Liquid Smoke Products*

Pyrolysis is a decomposition process of *Kesambi* leaves with an average combustion heat between 150-200ºC. *Kesambi* leaves in the pyrolysis tube can only fill half the parts, so that all the *Kesambi* leaves in the pyrolysis tube can burn properly, because the combustion process occurs indirectly.

After 1 hour the burning process takes place, smoke will flow through the smoke conduit pipe, a heavy fraction of the smoke portion will be captured by cyclone the catcher tar and fractions will flow towards the condenser pipe in the form of a coil that is cooled by water in the condenser tube with water on condenser tube so that smoke will be produced in the form of liquid. At first indeed smoke comes out, but then 5-10 minutes later results will come out in the form of liquid smoke. At first indeed smoke comes out, but then 5-10 minutes later results will come out in the form of liquid smoke. This process will end if the device does not emit liquid smoke again which takes an average of 6-8 hours.

D. *Pyirolysis Performance*

The quality parameters of liquid smoke include the determination of yield, pH, phenol compounds, acid content, carbonyl compounds and benzo(a)pyrene. Performance parameters of liquid smoke tools include the determination of the percentage of liquid smoke, the percentage of charcoal, missing components and the capacity of the tool / tool performance.

E. *Economic Analysis*

Liquid smoke pyrolysis operation, the cost of operating the tool is calculated by calculating the fixed costs and variable costs [8].

IV. RESULTS

Performance testing of tools can be carried out if the tools are ready to be used with proper installation of tool components, so that the quality and quantity of liquid smoke are good result. Good performance testing can be seen from the yield and high-capacity tool.

A. *Pyirolysis Performance*

The amount of liquid smoke produced with 20 kg of kesambi leaves as raw material was 6.447 kg, charcoal weight is 13.53 kg and the tar weight is 0.092 kg. The resulting liquid smoke is still a liquid that smells of pungent smoke. From this process, 3 fractions were obtained, namely solid fractions in the form of charcoal with high quality, heavy fraction in the form of tar, light fraction in the form of smoke and methane gas. Liquid smoke which obtained is a third grade cannot be used for food preservatives because it still contains dangerous ingredients that are carcinogenic. Material it must be decanted for 1 night so that the remaining tar can separate from liquid smoke, after that it is purified through the process of distillation and filtration with zeolites and activated charcoal to obtain grade 2 liquid smoke that can be used as a preservative. Food and flavor food additives.

In determining the performance of the tool it must calculate the working capacity of the tool and the yield produced. The working capacity of a pyrolysis tool is determined by the amount of raw material burned in pyrolysis per unit time. The working capacity of a pyrolysis tool is determined by the amount of raw material burned in pyrolysis per unit time. Meanwhile, the yield is the ratio between the weight of the product divided by initial weight multiplied by 100%. With a condenser of 1.84 m and pyrolysis time between 2.5 to 6 hours, the magnitude of the tool's performance is 1.0663 (kg / hour). Where as, the yield obtained is 31.665%. Quality of the liquid smoke produced, based on GC / MS analysis, the liquid smoke produced contains several compounds including those shown in Tables 1 and 2.

TABLE I. THE RESULTS OF PHYSICAL ANALYSIS OF LIQUID SMOKE

Parameter	**Analysis Results**			**Standard of wood vinegar quality in Japan 2001**	
	Grade 3	***Grade 2***	***Grade 1***	***Wood Vinegar***	***Distilled wood vinegar***
pH value	2.25	2.2	2.17	1.5-3.7	1.5-3.7
Color	blackish brown	yellow	colorless	Yellow Pale Reddish brown Reddish brown	Colorless Pale yellow Pale reddish brown
Transparency	Murky	Somewhat murky	Transparent	Transparent	Transparent
Floating matters	Tar	Floating matters	No Floating matters	No Floating matters	No Floating matters

TABLE II. THE RESULTS OF ANALYSIS PROXIMATE

	Unit of Measure	Analysis Results	
		Grade 3	***Grade 1***
Asam	%	13.63	9.78
Fenol	%	3.21	2.57
Karbonil	%	14.13	10.07
Benzo@pyrene	µg/kg	6.13	Not Detected

The performance of this tool is already high, producing liquid smoke with good phenol, acid content, pH value and good benzo(a)pyrene content (according to the discussion in each part above).

B. Economic Analysis of Pyrolysis Tools

Economic analysis of liquid smoke pyrolysis by calculating the cost of principal the operation of the tool is calculated using the equation [3]. So we get the following results: basic costs for producing smoke liquid *kesambi* leaves was Rp. 1.317/kg and BEP (breakeven point) 118,158 kg / year. Low production costs and BEP value from liquid smoke of *kesambi* leaves with LPG fuel stated that the liquid smoke of the *kesambi* leaves is feasible to produce.

V. CONCLUSION

Kesambi leaf liquid smoke pyrolysator is able to produce well, but still in limited quantities because the pyrolysis tube is only filled in half so that the combustion process in the tube is perfect.

Capacity of the kesambi leaf liquid pyrolysis tool production is 1,0663 kg / hour, the yield produced is 31,655%. while the yield of distillation is 95% and the yield of filtration results is 98.5%. So the distillate from filtration is pure from carcinogenic compounds. Quality of grade 1 liquid smoke produced is phenol compound 3.57%, acid compound is 9.8%, carbonyl compound is 10.07% and not benzo (a) pyrene is detected.

Results of an economic analysis of the operation of this pyrolysis tool are obtained costs principal of 1,317 / kg and BEP 118,158 kg / year.

Low production costs and BEP value from liquid smoke of kesambi leaves with LPG fuel stated that the liquid smoke of the kesambi leaves is feasible to produce.

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