
Improving Production of Liquid Smoke from Candlenut Shell by Pyrolysis Process

Production of
Liquid Smoke

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Abstract

Purpose – The purpose of this research is to study the process conditions that give best yield and expected compositions of liquid smoke products that result during the pyrolysis process relying on predetermined variables.

Design/Methodology/Approach – Pyrolysis process running times are varied, that is, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, and 6 hourly. Condensing temperature maintained remained 25–30 °C. Products identification was applied by using gas chromatography mass spectroscopy.

Findings – Based on the research output, it was concluded that process conditions which give maximum yield were achieved when using double unit condenser (DUC) and time optional four hours, and it provides maximum volume liquid smoke product, and compositions of pyrolysis products. The process also created seven components, namely naphthalene, propanoic acid, 3,7 nanodiena, 2 metilguaiakol, 2-metoksi 4-methyl phenol, 4 ethyl-2 metoksil phenol, oxybanzene. Applying DUC during condensation phase may increase condensing force thereafter obtaining resulted products between 200% and 300% rather than using single unit condenser (SUC).

Research Limitations/Implications – This research was conducted on a fixed batch reactor made of a metal plate with a thickness of 3.0 mm. It carries 200 kg in capacity. In this phase, the moisture of candlenut shells might be kept in 10–12.5% wt. Process temperature applied ranged within 350–500 °C.

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Originality/Value – In addition the study increased the theoretical of understanding about pyrolysis process and Improving the production of liquid smoke from candlenut shell by pyrolysis process using the method of vapor condensation (Double unit condensor).

Keywords Candlenut shell, liquid smoke, pyrolysis, single unit condenser, double unit condenser

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1. Introduction

Hazel nut or candlenut (*Aleurites moluccana*) is classified as one of the huge available natural resources in Indonesia, being considered as a wide prospect marketing commodity both in domestic and overseas. Candlenut shell resulted from its plantations is claimed as one of the numerous solid waste biomass, containing organic compounds, such as hemicelluloses, cellulose, and lignin.

Utilizing waste of biomass as the source of bio oil or liquid smoke thorough pyrolysis are commonly used. Thus, by using several raw materials, such as coconut shells (Haji *et al.*, 2007), palm stems, empty fruit bunches of palm (Fahlepy and Suwardin, 2015), palm shell, saw dust, straw, wheat, grass (Bridgwater, 2010), pine nut shells (Darmadji, 1996), jatropha seeds, Karanja Niger seeds (Purnima, 2012), pine woods, corn cob (Chen *et al.*, 2016), date seeds, coconut husks, plum seeds, waste residue, etc. However, utilizing solid waste materials from candlenut shells to be processed resulting liquid smoke through pyrolysis process are reported never applied.

Characteristic of pyrolysis products consisting of liquid smoke as a prime product, bio char as a solid state product resulted in tar and gas (Shen *et al.*, 2015). Hereafter, compositions gained by biomass pyrolysis process are classified by its chemical prosperities, thus phenol, carbonil compound, formaldehyde, acid compound, and hydro polisiklis aromatis (HPA) such as benzo (@) pyrene in which claimed badness due to carcinogenic formed in wood pyrolysis process.

Liquid smoke has potential use for all natural antimicrobial in commercial application where smoke flavor is desired, which uses in food application (Saloko *et al.*, 2014; Soazo *et al.*, 2016), because liquid smoke memiliki manfaat sebagai antihydroxidative and antimicrobial (Ricke- and Crandall, 2014). The smoking of meat has been used as a presentitative technique for centuries (Kan *et al.*, 2015). Redestillasi liquid smoke from oil palm shell has been proven effective as fresh fish preservative due to its antibacterial activity (Chen and Lin, 2015). Latex coagulant is one of the important factor of natural rubber because it will deremine the quality of rubber end product. One of the coogulant which produces good quality natural rubber is liquid smoke (Fahlepy and Suwardin, 2015).

The purpose of this research was to find out (i) treatment procedures which result in best yield, (ii) composition of of liquid smoke yielded from pyrolysis process using predetermined variables, and (iii) the effect of double unit and single unit condenser (SUC) on yield improvement of liquid smoke using pyrolysis process.

2. Materials and Methods

This research conducted in several stages, starting from raw material preparation (candlenut shell) that was harvested from several villages plantations within North Aceh district.

2.1. Raw material preparation

The raw material is using candlenut shell. This is collected by locals from several villages in north Aceh resort. It is dried naturally by sun to reduce moisture content around 10–15% (Figure 1).



Figure 1.
The Raw Material of
Candlenut Shell

2.2. Pyrolysis Stage Methode

In this phase, dried candlenut shells to be weighed at 200 kg and fed into pyrolysis tube of reactor which is made up of metal plate with thickness in 3 mm. In this stage, humidity of candlenut shells should be kept at 10–12.5% and not to be crushed to smaller size as it has been appropriately sized. Process temperature maintained within 350–550 °C. Time of pyrolysis presets, that is, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6 hourly. Pyrolysis equipments to be used are SUC and double unit condenser (DUC) intended to observe comparatively the effects of both condensers upon condenser increasing efficiency of pyrolysis products obtained. Hereafter, the products collected into storage tank. Condensing temperature to be kept at 25–30 °C. The next step is to identify the products by using gas chromatography mass spectrometry (GCMS). Calibration of area chromatography to be done by analyzing response factors over chemical group appearances which firstly determined by using *campuran standard* and *senyawa reference* (untuk cairan Tetraline untuk gas methane) with a very concentrations. Unidentified peaks of chromatography. Figure 2 covers a 5% of total area presented by average response factor. Characteristic of

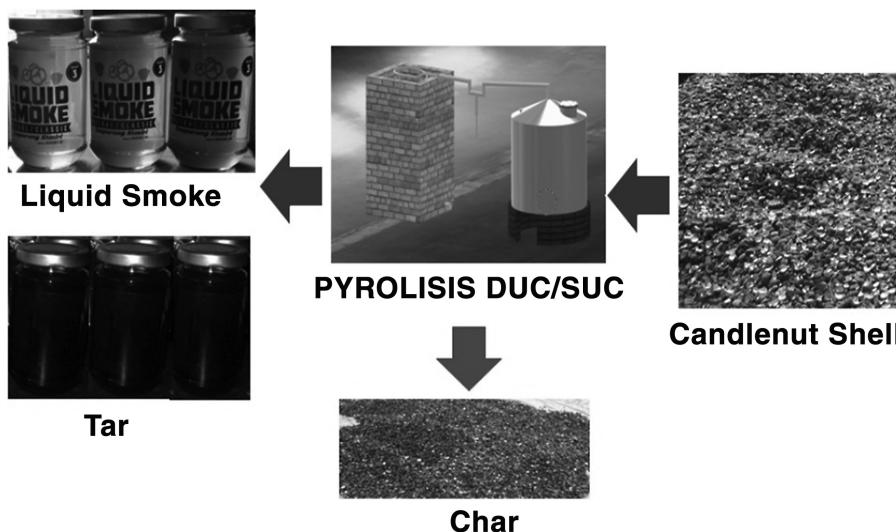


Figure 2.
The Schematic
Diagram of
Candlenut Shell
Pyrolysis Process
Using Fix Batch
Reactor DUC and
SUC

liquid products may be observed by using Carlo Elba EA 1108 that equipped with elemental microanalyzer. By this instrument, a liquid smoke–water mixture can be observed (Carl Fische Technic, Iram 21320). Calorie value of liquid product–gas mixture to be corrected depending on water content calculated by Dulong's method (Figure 2).

2.3. Product analysis stage

Hence we undertook the identification of liquid smoke product yielded by optimum condition and evaluated the characteristics of the product with several variables. GCMS was applied in identifying products. Moreover, analyzing stage was followed by measuring acidity.

3. Results and discussion

3.1. Result

3.1.1. Pyrolysis Condition. Optimum process condition on candlenut shells resulting maximum gain of liquid smoke by pyrolysis, by applying vapor condensing method, using DUC and SUC with running time 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, and 6 hourly. It is shown in Figure 4, where best performance of pyrolysis process to achieve maximum quantity of liquid smoke derived from candlenut shells resulted by using DUC within running time four hours and for SUC within 3.5 hours.

3.1.2 Affection of condenser's types upon increasing yield of liquid smoke. Optimum process conditions resulting maximum liquid smoke product in pyrolysis of candlenut shells by applying vapor condensing method of SUC that takes pyrolysis running time four hours. Best performance process conditions achieved by applying DUC with running time four hours in which total yield of liquid smoke obtained around 1,320 mL. It is clearly shown in Figure 3.

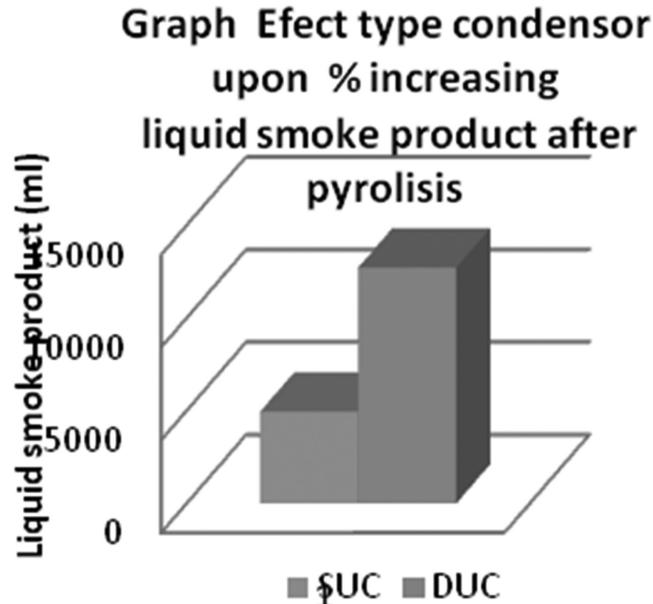


Figure 3.
Graph Effect
Condensor SUC and
DUC Serta

The percentage increase of the candlenut shell liquid smoke products using double-type condenser showed significant influence towards smoke liquid production compare to using single-type condensor. The increase reached 300%. It can be seen in Figure 3.

3.1.3. Product Analisa Stage. Analisa identification of the product by GCMS dapat dilihat pada Table 1.

3.2. Discussion

Optimum process condition on candlenut shells resulted in maximum gain of liquid smoke by pyrolysis, by applying vapor condensing method using DUC and SUC with running time 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, and 6 hourly. It is shown in Figure 4, that the best performance of pyrolysis process to achieve maximum quantity of liquid smoke derived from candlenut shells resulted by using DUC within running time of four hours and for SUC within 3.5 hours.

No.	Name Komponen	% Area
1	Oxybenzene	2,36
2	Propanoic acid	2,26
3	2-Methoxy phenol	73,44
4	2-Methoxy-4-methyl-phenol	13,05
5	8-Methyl-3,7-nonadien-2-one	3,12
6	4-Ethyl-2-methoxy-phenol	2,58
7	Naphthalene	3,19
		100

Table 1.
Nama Senyawa Hasil
Pyrolysis Pada
Kondisi Optimum
Produk Pyrolisa asap
Cair Tempurung
Kemiri

Graph Effect type condensor upon Volume liquid smoke product after pyrolysis

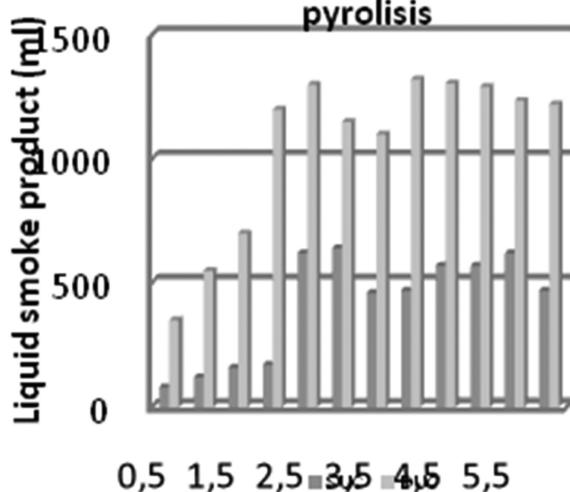


Figure 4.
Effect Time n Type
Kondensor upon
Liquid Smoke
Product

Analisa Identification of The product by GCMS can be seeee in Table 1. The compositions of pyrolysis liquid smoke obtained are also created seven components, namely nepthalene, propanoic acid, 3,7 nanodienia, 2 metilguaiakol, 2-metoksi 4-methyl phenol, 4 ethyl-2 metoksil phenol, oxybanzene. Dari grafik diatas juga dapat dilihat kandungan atau persen fenol yang tinggi terdapat pada asap cair tempurung kemiri sebesar 73,44%.

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4. Conclusion

From this research, the conclusion can be described as follows:

The best process condition for maximum performance of liquid smoke during pyrolysis of candlenut shell with condensing vapor method was by using SUC at 3.5 hours and DUC at 4 hours, respectively, which obtained total yield araound 456 mL and 13,200 mL, pH 4.23–4.78 condensing mechanism using the type of condensor DUC obtained liquid smoke product is higher than using the type of condensor SUC. The increasing percentage liquid smoke candlenut shell was obtained by using DUC to 300%.

Identification of products by using GCMS at optimum conditions shows that liquid smoke candlenut shell consists of components such as oxybenzene 2.36%, propanoic acid 2.26%, 2-methoxy phenol 73,44%, 2-methoxy-4-methyl-phenol 13.05%, 8-methyl-3,7-nonenadien-2-one 3.12%, 4-ethyl-2-methoxy-phenol 2.58%, and dan nepthalene 3.19%.

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