Quality Improvement of Liquid Smoke of Coconut Shell by Tar Scrubber

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Abstract: One of the most challenging issues concerning to the pyrolysis of liquid smoke coconut shell is the presence of tar. The acidity, water content, density and content analysis of liquid smoke using coconut shell which produced at 500ºC using pyrolysis reactor equipped with a tar scrubber were compared to liquid smoke produced conventionally. Characterization of acidity of the liquid was measured by pH meter by adhering to ASTM E70, water content by using volumetric Karl Fischer titration method following ASTM E203 and ASTM D1744 method, the density by AOC 1995, and dichloromethane extracts content by gas chromatography-mass spectrometry (GC-MS). The results showed that the pH range of liquid smoke was pH 2.4 to 2.6 with the water content of 89.970 to 94.593%, and the density of 1.0118 to 1.0036 g/mL. The carbonyl and phenol content were 5.05 to 6.473% and 85.057 to 90.024% respectively. From the results can be concluded that the quality of liquid smoke produced by tar scrubber is better than the quality of liquid produced by conventional method.

1 INTRODUCTION

Coconut shell liquid smoke is a result of pyrolysis of coconut shell or condensation of steam distillation. The constituents of the liquid smoke are obtained from thermal degradation reactions of cellulose, hemicellulose, and lignin. Hemicellulose owned the highest CO_2, lignin generated the highest CH_4 and cellulose produced the highest CO characterized by the largest HHV (Zhao, Jiang and Chen, 2017).

In the process of pyrolysis also produced liquid smoke, tar and non-condensable gases. Liquid smoke which is a by-product of the charcoal industry has high economic value when compared to being discharged into the atmosphere. Liquid smoke is obtained from dew condensation resulting from decomposition of organic compounds during the pyrolysis process. The content of liquid smoke from pyrolysis is phenol compound of 90.75%, carbonyl 3.71% and alcohol 1,81%, the compound is antimicrobial which can preserve food (Hadanu and Apituley, 2016). The application of liquid smoke is mainly associated with the functional properties of liquid smoke, including as an antioxidant, antibacterial, antifungal, and its potential in forming the product.

Antimicrobial properties can inhibit the activity of spoilage and spoilage microbes in food so that it can extend the shelf life of food products (Olatunde and Benjakul, 2018). In addition, liquid smoke can also have an effect on distinctive taste, color, and aroma. Some types of agricultural waste such as corn cobs, rice husks, peanut shells, coconut shells, coconut fiber, mangrove wood, pine and others contain phenols and antibacterial properties that can preserve and give flavor to food products (Dungani et al., 2016).

Liquid smoke produced from coconut shell needs further processing because it contains higher levels of benzopyridene containing toxic thus liquid smoke from coconut shell is not yet suitable for use (Budaraga et al., 2016). The major proportion of

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commercial full-strength liquid smoke to be composed of water (11–92%), tar (1–17%), acids (2.8–9.5%), carbonyl containing compounds (2.6–4.6%) and phenol derivatives (0.2–2.9%) (Baltes et al., 1981). Further treatment is needed to reduce levels of toxic compounds, eliminate tar, increase liquid smoke yield and its quality.

The general method used in removing tar from liquid smoke is redestilation. Redestilation is the process of purifying liquid smoke based on differences in the boiling point of liquid smoke. There have been many studies doing liquid smoke redestilation (Darmadji, 2002; Budaraga et al., 2016; Ketut Budaraga et al., 2016). At present, the method offered in removing tar is wet scrubber because it is simple, economical and high efficiency. Some studies use this method for removing tar in syngas.

The objective of this study was to determine important chemical characteristics of a full-strength liquid smoke from tar scrubber. The chemical volatile and semi-volatile constituents of these product were identified using gas chromatography-mass spectrometry (GC-MS) analysis. pH, acidity, density were also determined.

2 MATERIALS AND METHODS

2.1 Materials

Raw material used in this study was coconut shell from coconut shell charcoal industry, Johor, Medan, Indonesia.

2.2 Equipment

In this study, the equipment used were a set of pyrolysis tar scrubber reactor, pH meter, pycnometer, analytical balance, Karl Fischer coulometric titrator and GC-MS.

2.3 Liquid Smoke Production

Production of liquid smoke was done by pyrolysis. The pyrolysis reactor was equipped with a tar scrubber which could be charged with as much as 500 kg of material. The reactor cover was connected by a pipeline to the cooling tubes used to condense the fumes and generate the liquid smoke. After all materials were inserted into the furnace, it was closed, the condenser was set, and the cooling tube was streamed with cold water. Pyrolysis was carried out at a temperature 500°C for 8 hours.

2.4 Characterization

Acidity of liquid smoke was characterized by pH meter, water content by using volumetric Karl Fischer titration, the density by AOC 1995, and dichloromethane extracts content by gas chromatography-mass spectrometry (GC-MS).

3 RESULTS AND DISCUSSION

3.1 Liquid Smoke Chemical Components

Liquid smoke compositions are obtained from pyrolysis of coconut shell. The traditional liquid smoke manufacturing saw dust pyrolyzed in temperature ranges of 350-600ºC and under atmospheric pressure conditions. In this research, the liquid smoke was obtained from thermal degradation reactions of cellulose, hemicellulose, and lignin. From a proximate components standpoint, the three major components of coconut shell are cellulose, hemicellulose, and lignin . The pyrolysis of lignin was reported at around 310-500 ºC and yielded the major source of phenols (Martinez et al., 2007). In the other research, the hemicellulose yielded furan, furan derivatives, and a series of aliphatic carboxylic acids (Siskos et al., 2007).

The quality of liquid smoke is very dependent on the composition of chemical compounds contained in liquid smoke. The compounds contained in liquid smoke are strongly influenced by the conditions of pyrolysis and types of raw materials (Budaraga et al., 2016). This is due to the large levels of cellulose and hemicellulose from each ingredient. Cellulose pyrolysis takes place in two stages, namely the first stage is an acid hydrolysis reaction followed by dehydration to produce glucose, while the second stage is the formation of acetic acid and homologous together with water and a small amount of furan and phenol (Collard and Blin, 2014).

Identification of phenol and carbonyl were detected gas chromatography-mass spectrometer in dichloromethane fractions. Results were shown on Table 1 in which phenol ranged from 85.057 – 90.024% while carbonyl from 5.05 – 6.473%. This shown that there were an increase in the chemical components produced by pyrolysis tar scrubber.

Table 1: Chemical Compenents of Liquid Smoke.

Method	Chemical Components	(%) Area
Tar Scrubber	Phenol	90.024
	Carbonyl	6.473
Conventional	Phenol	85.057
	Carbonyl	5.05

3.2 Density

Specific gravity is the relative ratio between the density of a substance and the density of pure water. The Table 1 below shows the effect of the results of pyrolysis by conventional methods and tar scrubbers on the specific gravity of liquid smoke.

From the Table 2 it can be seen that the specific gravity of liquid smoke from the tar scrubber at a temperature of 500ºC has a higher value than the value of the specific gravity of liquid smoke in the conventional method.

Table 2: Density of Liquid Smoke.

Method	Density (g/mL)
Tar Scrubber	1.0118
Conventional	1.0036

3.3 Acidity

Acetic acid compounds are classified as acid compounds that affect the pH of liquid smoke and taste and aging of smoke products. In addition, phenol levels also affect the pH of liquid smoke because phenol has acidic properties which are the influence of aromatic rings. The pH value is one of the quality parameters of liquid smoke produced. The pH measurement was carried out on the liquid smoke from the pyrolysis results and the distillation results from each material with the results obtained as shown in Table 3.

Table 3: Acidity of Liquid Smoke.

Method	Acidity (pH)
Tar scrubbe	2.4
Conventional	2.6

The tendency to decrease the pH of liquid smoke is because the content of Acetic acid and phenol compounds increases after distillation. The higher the total phenol level in liquid smoke, the lower the pH value or more acidic.

3.4 Water Content

From the Table 4. below it can be concluded that the higher the pyrolysis temperature, the lower the water content contained in liquid smoke. At the conventional method was lower temperature than tar scrubber method. The water content contained in liquid smoke was quite large because this temperature was evaporated and condensed. Whereas at temperatures of 500ºC there is a decomposition of components of organic matter contained in wood to produce liquid smoke with a more concentrated color and water content which tends to decrease.

Table 4: Water Content of Liquid Smoke.

Method	Water Content (%)
Tar Scrubber	89.970
Conventional	94.593

4 CONCLUSIONS

Optimum condition obtained through hydrogel Generally, the manufacture of liquid smoke by the pyrolysis tar scrubber method can improve liquid smoke quality. In addition, the most phenol and carbonyl contents were produced in tar scrubber method.

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