

The Effect of Durian Husk and Coconut Shell Combination in the Liquid Smoke Generation: A Review

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ABSTRACT

The husk of durian can be used as a source of cellulose, hemicellulose, lignin, and pectin to generate liquid smoke, and there are several types of researches that have done this. Liquid smokes can be used as natural food preservation because of the presence of antibacterial substance, there are two important compounds i.e., phenol and acetic acid. There are several factors influencing the concentration of an antimicrobial substance in liquid smoke, one of them is the temperature of the pyrolysis, as well as the type of wood used to generate the smoke. The type of wood defines the biomass content of lignin, cellulose, and hemicellulose, and this has been proven through two-way ANOVA analysis to be a significant factor in the concentration of phenol and acetic acid in liquid smoke. Meanwhile, temperature is not a significant factor in the generation of phenol and acetic acid. Durian husk has low lignin and hemicellulose content so coconut shell is added to increase the lignin and hemicellulose in the feed. This study aimed to obtain the best composition of durian husk and coconut shell in the liquid smoke generation based on phenol and acetic acid. Reviewing the literature through systematic review and meta-analysis was chosen as the method to determine the best variation of composition. The variations ratio between durian husk and coconut shell were 5:0; 4:1; 3:2; 2:3; 1:4 and 0:5 with a total mass of 5 kg and with temperature variation of 300°C and 400°C. The best variation was DTK6 at 300°C, pyrolysis of 5 kg coconut shell which produced the highest amount of phenol and acetic acid with the value of 2.502% and 2.572%.

Keywords: durian husk, coconut shell, liquid smoke, phenol, acetic acid, pyrolysis

1. INTRODUCTION

Durian is Indonesia's fifth most cultivated fruit with a total production of 1,142,102 tons in 2018 [1]. The husk of durian has a mass of 60-85% of the total mass of durian [2]. Usually, it becomes waste which will then be burned or allowed to decompose. The gas resulted from the burning process may pollute the air and may harm the environment. The husk can be used as a source of cellulose, hemicellulose, lignin, and pectin [3]. Several researchers have tried to process the husk to produce briquettes [4], insect repellent and fungus inhibitor cream from the extract [5], and liquid smoke [6].

Liquid smoke is the product of wooden material in the pyrolysis process. Wooden material is placed in a chamber where heat is applied intensely. It causes the wood to smolder (not burn) and release the gases.

These gases are quickly flown through a condenser then it becomes liquid. In order to be used as natural food preservation, liquid smoke needs to have an antibacterial substance which is made from two important compounds i.e. phenolic and acid compounds. The type of wood defines lignocellulose content such as lignin, cellulose, and hemicellulose. The lignocellulose content will affect the phenolic and acid compound of liquid smoke. Because of its high cellulose and low lignin content, the durian husk needs additional lignin substance to generate the liquid smoke. Liquid smoke contains phenols that act as antimicrobials that inhibit microbial growth [7]. The phenolic compound can prolong the lag phase of microbial growth, as well as inhibit fat oxidation by preventing the formation of free radicals, thereby reducing the formation of off-flavors [8]. Phenols also function as antioxidants that inhibit fat oxidation so

that it can maintain the taste of food coated with liquid smoke [9].

Another antibacterial compound found in liquid smoke is acetic acid. 5% concentration of acetic acid has a bactericidal effect that inhibits cell wall formation, toxic to bacterial cells, and kills these bacteria. It can acidify the cytoplasm, damage the surface tension of the membrane and eliminate the food transport on the membrane which causes the death of bacteria. The H⁺ ion in acetic acid will lower the pH of the bacterial environment and cause enzyme denaturation, thereby reducing the viability of bacterial cells [10].

The husk of durian has a cellulose content around of 60% [12]. It makes the durian husk gristly and difficult to cultivate. Pyrolysis of durian husk in 450°C gives the relative percentage of phenol content around 1.65% and acetic acid 39.73% [6]. While the coconut shell has a lignin content of 33.3% [13] and becomes this material hard. The pyrolysis of coconut shell at 500°C for 4 hours produced the liquid smoke with 12.93% of phenol and 46.56% of acetic acid as the derivate of acid compound [11]. It is believed that coconut shells can be used as a source of additional lignin in the liquid smoke generation. Table 1 present the biomass composition of durian husk and coconut shell. The combination of durian husk and coconut shell in a good composition could generate liquid smoke with a high phenolic and acid compound. The objective of this study was to obtain the best composition of durian husk and coconut shell in the liquid smoke generation based on the phenol and acetic acid concentration.

Table 1. Biomass composition of durians husk [12] and coconut shell [13]

Biomass content (%)	Durian Husk	Coconut shell
Hemicellulose	13.09	27.70
Cellulose	60.45	27.31
Lignin	15.45	33.30

2. METHODS

Table 2. Liquid smoke from different wooden material

Ref	Biomass	Quantity (gram)	Biomass content (gram)			Temp Pyrolysis (°C)	phenol (%)	Acetic acids (%)
			cellulose	Hemicellulose	Lignin			
[14]	Coconut shell	30000	8193	8310	9990	300	3.48	
						400	4.63	
[15]	Coconut fiber	3000	670.5	569.7	1293.3	300	0.2	0.12
						400	0.1767	0.12
	Coconut shell	3000	819.3	831	999	300	1.6067	1.62
						400	1.73	1.15
Cinnamon	3000	900	900	639.9	710.1	300	0.6567	0.85
						400	0.57	0.72
[16]	Betel nut husk	2000	800	40	360	300	0.489	25.2
						400	0.541	27
[17]	Durian Husk	3000	1813.8	392,7	463,5	300	2.08	4.13
[18]	Durian Husk	2500	1511,25	327,25	386,25	300		0.9

A systematic review of the literature was chosen as the method to examine the effect of biomass content from various raw materials of biomass in a liquid smoke generation.

2.1. Analysis of literature result

Identifying the literature on a similar subject became the first step of the systematic review. The literature with pyrolysis of biomass at 300°C and 400°C which contain phenol and acetic acid data without the purification process were chosen to be analyzed.

Meta-analysis analytical method was used to determine the correlation of biomass contain to phenol and acetic acid concentration of the liquid smoke by collecting the result of the literature. Analysis of variance (ANOVA) determined the significance of lignocellulose to the quality of liquid smoke produced by pyrolysis.

2.2. Determining the amount of compound being produced

The analytical result of the influencing lignocellulose content to the phenol and acetic acid became the basis to predict the effect of durian husk and coconut shell combination as the raw material variation. The ratio variable between durian husk and coconut shell were 5:0; 4:1; 3:2; 2:3; 1:4 and 0:5 with a total mass of 5 kg with temperature variation of 300°C and 400°C.

3. RESULT AND DISCUSSION

The result of the literature review was shown in Table 2. The amount of the lignocellulose in each pyrolysis process was calculated based on the lignocellulose composition of each biomass. The data in Table 2 was used to prove the significant effect of lignocellulose and to calculate phenol and acetic acid in liquid smoke from the combination of durian husk and coconut shell.

Table 3. Analytical result of the lignocellulose Influence on the phenol concentration by ANOVA

Source of Variation	F	P-value	F critical
Lignocellulose	41.383	0.002	6.388
Temperature	1.007	0.372	7.709
α		0.05	

Table 4. Analytical result of the lignocellulose Influence on the acetic acid concentration by ANOVA

Source of Variation	F	P-value	F critical
Lignocellulose	33.407	0.008	9.277
Temperature	1.825	0.270	10.128
α		0.05	

The statistic analytical method using two-way ANOVA without replication was used to determine the effect of lignocellulose on the phenol and acetic acid content of the liquid smoke generation. The F value of lignocellulose in table 3 and 4 were greater than the F-critical while the P-value was smaller than α so that lignocellulose became a significant factor to the phenol and acetic acid concentration. The F value of the temperature in table 3 and 4 gave the opposite result; they were smaller than the F-critical while the P-value was greater than α . It meant that the temperature change from 300°C to 400°C of this wood pyrolysis did not give a significant effect on the phenol and acetic acid content of the liquid smoke. Other study states that temperature of pyrolysis is one of the factors that affect the composition of liquid smoke [19] because the decomposition of cellulose, hemicellulose and lignin occurs at different temperature and each constituent produce different amount of phenolic compound and acetic acid [20]. The differences of this result occurred possibly because the data of temperature difference in this data review in a small range (only 100°C) or because the temperature variation being analyzed was too little.

After it was proven that lignocellulose was a significant factor in the resulting amount of phenolic compound and acetic acid, then the data from Table 2 were further analyzed. Each constituent of lignocellulose had a different chemical compound and structure. Hemicellulose consists of various saccharides that were easy to degrade into volatile matters. Meanwhile, cellulose consisted of long polymer glucose without branches that had high thermal stability, and lignin consisted of aromatic rings with various branches [21].

The different chemical compounds in each constituent decomposed at various temperatures and released different products in pyrolysis. The decomposition of hemicellulose generated most of the acetic; degradation of cellulose mainly produces furans, and degradation of lignin released phenols. The amount of

acetic acid and phenol concentration in the liquid smoke compare to the quantity of hemicellulose and lignin content of the biomass could be seen in figure 1.[22].

The correlation between the quantity of hemicellulose to acetic acid and lignin to phenol was shown in Figure 1 and Figure 2. The equations from the linear regression were used to estimate the amount of phenol and acetic acid concentration from the pyrolysis of the durian husk and coconut shell combination.

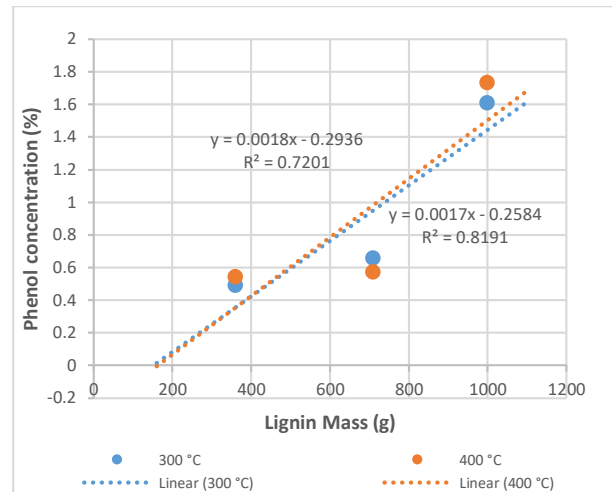


Figure 1. The correlation of mass of lignin and phenol concentration in liquid smoke at 300°C and 400°C

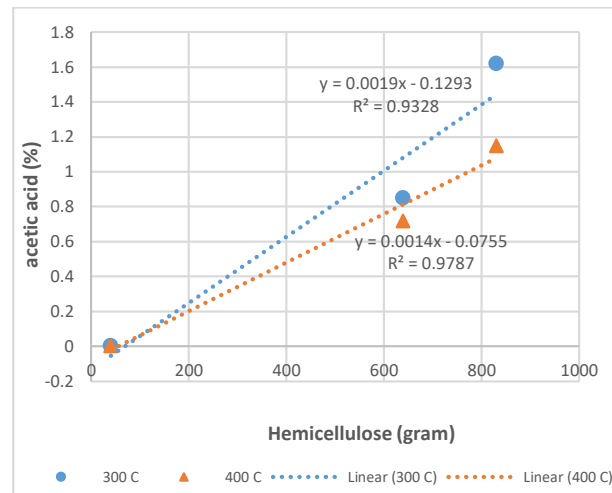


Figure 2. The correlation of mass of hemicellulose and acetic acid concentration in liquid smoke at 300°C and 400°C

Both figures showed that a higher amount of lignin and hemicellulose would result in a higher concentration of phenols and acetic acid in liquid smokes. Hence, liquid smoke feed needed to have a high amount of lignin and hemicellulose. Durian husk and coconut shell had different concentrations of lignin and hemicellulose. The ratio combination of them was determined to give the highest amount of lignin and hemicellulose.

There were six ratio variables of the durian husk and coconut shell combination, i.e. 5:0, 4:1, 3:2, 2:3, 1:4, and 0:5, with the basis of total mass 5000 grams. The total of lignocellulose components in each ratio variation was shown in Table 5.

Table 5. The composition of Lignocellulose in Each Variation

Var	Total of Cellulose content (gr)	Total of Hemicellulose Content (gr)	Total of Lignin content (gr)
5:0	3022.5	654.5	772.5
4:1	2691.1	800.6	951
3:2	2359.7	946.7	1129.5
2:3	2028.3	1092.8	1308
1:4	1696.9	1238.9	1486.5
4:0	1365.5	1385	1665

The equation from regression in Fig. 1 and 2 was then used to determine the concentration of the phenol and acetic acid in liquid smoke of each variation. The results were shown in Fig. 3 for the phenol concentration and Fig. 4 for the acetic acid concentration. The phenol concentration in fig.3 at 400 °C tended to be higher than from 300 °C because lignin decomposition become phenols occurred at the wide range temperature from 300 to 500 °C [23]. The higher temperature of pyrolysis gave more energy for lignocellulose to be decomposed [19] and produced more phenol. On another hand, the acetic acid was mainly derived from the decomposition of hemicellulose that occurred mostly at 220-315°C [21]. The amount of acetic acid decreased at 400°C due to its decomposition at a higher temperature, which significantly occurred at 280-380°C. The acetic acid in pyrolysis which had a low concentration of O2 would decompose through oxidation [24] and the reaction expressed by:

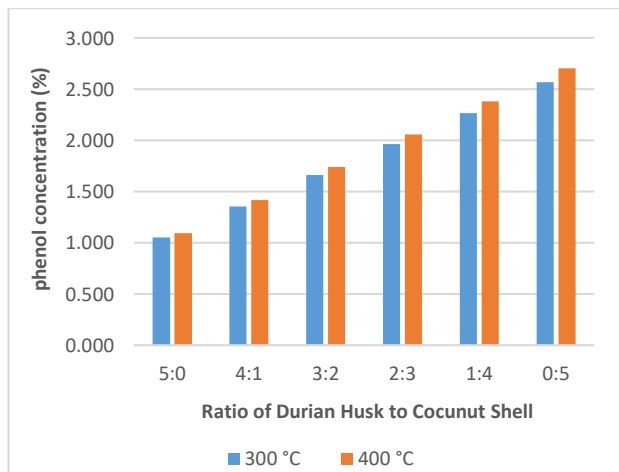
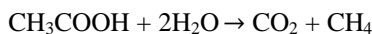


Figure 3. Phenol Concentration in Liquid Smoke from Each Variation at 300°C and 400°C

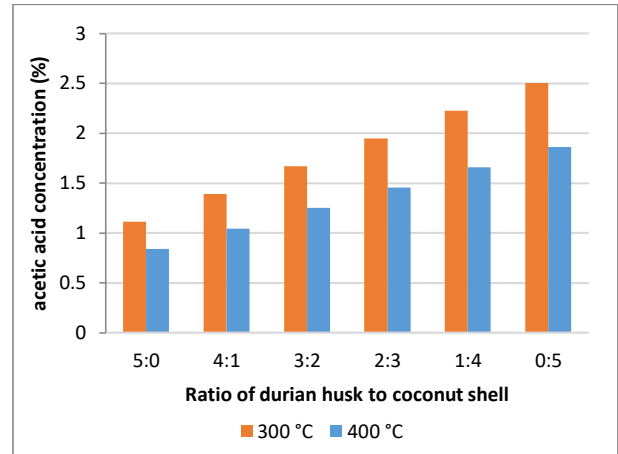


Figure 4. Acetic Acid Concentration in Liquid Smoke from Each Variation at 300°C and 400°C

The highest concentration of the phenol and acetic acid was predicted in ratio 0:5 of durian husk and coconut shell. This result happened because the durian husk had lower hemicellulose and lignin concentration compared to the coconut shell. Durian husk had a high amount of cellulose that decomposed to furan which could produce phenols through the catalytic process [25].

Therefore, the best ratio combination was 0:5 with the pyrolysis temperature of 300°C, with the concentration of acetic acid and phenol concentration were 2.502% and 2.572% respectively.

4. CONCLUSION

Lignocellulose was a significant factor in phenol and acetic acid concentration in liquid smoke, but each constituent of lignocellulose had a different role.

The phenol concentration in liquid smokes from pyrolysis at a temperature of 300 °C and 400 °C, mostly affected by lignin and acetic acid affected by hemicellulose.

The difference temperature of pyrolysis of 300°C and 400°C didn't show significant results, but still affected the concentration of phenol and acetic acid concentration in liquid smoke. Phenol concentration at 400°C was higher than 300°C meanwhile acetic acid concentration at 400°C decreased because of the decomposition.

The best ratio of the durian husk and coconut shell combination was 0:5 at 300°C from the pyrolysis of 5000 grams coconut shell which produced the highest amount of phenol and acetic acid concentration with the value of 2.502% and 2.572%.

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