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OPTIMIZATION OF MAKING LIQUID SMOKE FROM COCONUT SHELL AS ORGANIC DISINFECTANT USING TAGUCHI METHOD

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ABSTRACT

Liquid smoke is effective as a disinfectant and Contains anti-bacterial activity. Liquid smoke can inhibit bacterial growth because it contains phenolic compounds that can bind to bacterial proteins through hydrogen bonds, causing the protein structure to be damaged. Phenol can be found in a variety of consumer products including mouthwash. Phenol is irritating and corrosive to skin and mucous membranes. The shell liquid smoke product containing phenol and acetic acid has effects comparable to 70% alcohol to be used as a disinfectant at a phenol concentration of 12.5% and is safe to be used as a disinfectant. In the process of making liquid smoke, The quality of liquid smoke is influenced by the pyrolysis temperature, burning time, condensation temperature, and dry shell, so the optimization of the process of making quality coconut shell liquid smoke is made as an organic disinfectant using the Taguchi method, to achieve the specified percentage target to produce process standards. The method used is Taguchi. quality control method which combines level factors, namely the pyrolysis temperature factor, burning time, condensation temperature, and shell drying. The optimal results obtained were phenol compounds at rank 1 (A3) process (pyrolysis temperature $180^0 \leq T \leq 210^0$), rank 2 (B3) (pyrolysis time 5 hours), rank 3 (D2) (2 days shell drying time) and rank 4 (C1) (condensation temperature 30^0). And to be used as a disinfectant at a phenol concentration of 12.5% or close to the standard process (A3) (pyrolysis temperature $180^0 \leq T \leq 210^0$), (B1) (pyrolysis time 1 hour), (C3) (condensation temperature 40^0) and (D1) (long drying shell 0 days).

Keywords: Optimization Of Shell Liquid Smoke, Disinfectant, Taguchi Method

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1. INTRODUCTION

According to Hayati, (2018) Liquid smoke is the result of condensation or condensation of steam resulting from direct or indirect combustion which contains a lot of lignin, seselulosa, and other carbon compounds. Liquid smoke comes from natural ingredients, coconut shells, and so on. Generally, the compounds contained include phenol (C6H6O), carbonyl (C=O), acetic acid (C2H4O2), furan (C4H4O), alcohol, and ester (R-COOH) which have antimicrobial, anti-bacterial, and antioxidant effects. Liquid smoke can be used as an alternative organic disinfectant amid the COVID-19 pandemic.

According to Erlitasari et al, (2019). Liquid smoke is effective as a disinfectant, its content has anti-bacterial activity. Liquid smoke can inhibit bacterial growth because it contains phenolic compounds that can bind to bacterial proteins through hydrogen bonds, causing the protein structure to be damaged. The metabolic activity of bacterial cells catalyzed by protein will stop. Phenol can disrupt the integrity of the cytoplasmic plasma which results in the escape of macromolecules and ions from the bacterial cell so that the bacterial cell loses its shape and lysis occurs. Another compound contained in liquid smoke is carbonyl which functions to absorb extracellular enzymes produced by bacteria to form proteins.

The antimicrobial activity of liquid smoke was also obtained due to the presence of organic acid compounds. Acidic compounds function by lowering the pH in bacterial cells so that bacteria will release H+, but this process requires a large amount of energy so that all ATP reserves will be depleted and result in disruption of bacterial cell metabolism. Phenol is a colorless crystalline substance that has a characteristic odor. Phenol can be found in a variety of consumer products including mouthwash. Phenol is irritating and corrosive to skin and mucous membranes. The shell liquid smoke product containing phenol and acetic acid has effects comparable to 70% alcohol to be used as a disinfectant at a concentration of 12.5% and is safe to be used as a disinfectant.

Liquid smoke is the result of smoke condensation through the pyrolysis process at a temperature of around 300 to 5000C, liquid smoke contains various chemical components such as phenols, aldehydes, ketones, and organic acids, alcohols, and esters, (Guillen et al., 2001). phenolic compounds, acids, and alcohols can act as antioxidants and antimicrobials antibacterial and antifungal (Karseno et al., 2001). Thus, liquid smoke has the potential as a biopesticide to deal with the problem of pest pathogens (Nugroho & Aisyah, 2013). According to Kilinc & Cakli, (2012), stated that liquid smoke is now gaining popularity as a preservative for various food products and biopesticides to increase agricultural production. Furthermore, the liquid smoke produced in the pyrolysis process of coconut shells and coconut shells can be used as preservatives, insecticides, and medicines that provide considerable benefits to human life. The content of liquid smoke resulting from the pyrolysis of organic waste contains -butyrolactone compounds which have antifeedant activity against Spodoptera litura larvae. Wood vinegar is a multi-benefit product because it can function as plant fertilizer, hormone, and fertilizer, controlling plant-destroying organisms, and functions as an antiseptic (Hayati, 2018).

According to Nur, (2018), From the results of the analysis using GC-MS, the dominant compound that composes dirty liquid smoke consists of phenolic compounds, 2-methoxy phenol, 2,6-dimethoxy phenol, 1,2-benzenediol, 4 methyl catechol, and 3-methoxy-1,2-benzenediol. According to Erlitasari et al, (2019). Liquid smoke is effective as a disinfectant, its content has anti-bacterial activity. Liquid smoke can inhibit bacterial growth because it contains phenolic compounds that can bind to bacterial proteins through hydrogen bonds, causing the protein structure to be damaged. The metabolic activity of bacterial cells catalyzed by protein will stop. Phenol can also disrupt the integrity of the cytoplasm which results in the escape of macromolecules and ions from the bacterial cell so that the bacterial cell loses its shape and lysis occurs. Another compound contained in liquid smoke is carbonyl which functions to absorb extracellular enzymes produced by bacteria to form proteins. The antimicrobial activity of liquid smoke was also obtained due to the presence of organic acid compounds..

Disinfectants are chemicals used to inhibit or kill micro-organisms (e.g. bacteria, viruses, and fungi).disinfectants are not used on the skin and mucous membranes, because of the risk of irritating the skin and triggering cancer. Most of these disinfectants are broad-spectrum, meaning that they not only kill viruses but can also kill other

microorganisms that should be present in the environment, this will disturb the balance of the environment. The microorganisms in charge of decomposing the disinfectant chemicals also die and become extinct, so the disinfectants will stay in the environment longer. If this is the case, then the remaining disinfectant in the soil and water will be absorbed by plants and follow the food chain, namely to small plant-eating animals, large animals, and humans.

Organic disinfectants are natural ingredients that contain phenolic compounds, carbonyl acetic acid, and others, which can be decomposed, and contained in some plants, the content of which has anti-bacterial activity can inhibit bacterial growth because it contains phenolic compounds that can bind to bacterial proteins through hydrogen bonds, causing the protein structure to be damaged. The metabolic activity of bacterial cells catalyzed by protein will stop. Phenol can also disrupt the integrity of the cytoplasmic cytoplasm which results in the escape of macromolecules and ions from the bacterial cell so that the bacterial cell loses its shape and lysis occurs. Another compound contained in liquid smoke is carbonyl which functions to absorb extracellular enzymes produced by bacteria to form proteins. The antimicrobial activity of liquid smoke is also obtained due to the presence of organic acid compounds. Acidic compounds function by lowering the pH in bacterial cells so that bacteria will release H+, but this process requires a large amount of energy so that all ATP reserves will be depleted and result in disruption of bacterial cell metabolism (Sudjana, 1992).

Genichi Taguchi designed an experiment to get the factors that affect the response and its interaction with a minimum number of experiments and select the best factor level with certain criteria as optimal parameters. The Taguchi method uses a special set of matrices called Orthogonal Arrays (Peace, 1993). This standard matrix is a step to determine the minimum number of experiments that can provide as much information as possible on all the factors that affect the parameters. The goal of Taguchi's experiment is to design a way to minimize deviations from the quality characteristics of the target value.

2. METHODS

2.1. Preparation Phase

In this stage the preparation of materials and equipment is carried out, as for the tools and materials used include coconut shell and dry coconut husk type hybrid 100 kg 2-time experiment, while the tools used include: pyrolysis/combustion equipment, temperature thermometer to check the pyrolysis temperature and distillation temperature, and GC-MS for the analysis of compounds contained in liquid smoke.

2.2. Experiment Stage

In this experiment, 4 factors 3 levels were used. From the number of existing levels and factors, it can be determined the number of columns for the orthogonal matrix. By using orthogonal array matrix analysis, the calculation to determine the orthogonal array is obtained as follows:

*F(*number of factors) =4

Runs =18

Signal = 2Columns of L16 (4^5)

db(level) =3-1

= 2

Db (OAW) = *F x db (level)*

= 4 x 2 = 8 n = db (OA) + 1 = 9

Table 2.1 Standard Orthogonal Array Matrix L9

Exp. No	Control Factor				phenol	
	A	B	C	D	Exp 1	Exp 2
1	$100^0 \leq T \leq 150^0$	1	30^0	0 day		
2	$100^0 \leq T \leq 150^0$	3	35^0	1 day		
3	$100^0 \leq T \leq 150^0$	5	40^0	2 day		
4	$150^0 \leq T \leq 180^0$	1	35^0	2 day		
5	$150^0 \leq T \leq 180^0$	3	40^0	0 day		
6	$150^0 \leq T \leq 180^0$	5	30^0	1 day		
7	$180^0 \leq T \leq 210^0$	1	40^0	1 day		
8	$180^0 \leq T \leq 210^0$	3	30^0	2 day		
9	$180^0 \leq T \leq 210^0$	5	35^0	0 day		

3. FINDINGS AND DISCUSSION

3.1. Findings

In a normally distributed population, the assumption of normality needs to be checked for validity so that the next steps can be accounted for, for normality testing the data must be compiled in a frequency distribution list consisting of intervals between the observed frequencies. If the observed frequency is very close to the expected frequency, the value of X^2 will be small indicating a good match, if the observed frequency is large enough, from the expected frequency the value of X^2 will be large so that the suitability is bad. A good fit will lead to H_0 acceptance, while a bad fit will lead to H_0 rejection, so the critical region will fall to the right of the square distribution. For a significant level of , the critical value of X^2 (α) (dk) can be obtained in the chi-square distribution table, thus the critical area is $X^2 \geq X^2$ (α) (dk), (Sudjana, 1992).

3.2. Discussion

3.2.1Normality test

To test the similarity of several averages, as in the method of analysis of variance (ANOVA), it is assumed that the population has a homogeneous variance, namely yaitu $a_1^2 = a_2^2 = \ldots = a_k^2$ so it is necessary to test the homogeneity (similarity) of the normal population variance. From k (k >2) the population has an independent and normal distribution, each with variance.

$\alpha 1^2, a2^2, \ldots, ak^2$ Hypothesis will be tested:

$Ho : a1^2 = a^2 = \ldots = ak2^2$

H1: at least one equal sign is not valid.

With a significance level of , the Ho hypothesis is rejected if x^2 count $x^2 (1-\alpha)$ (dk) where $x^2 (1-\alpha)$ (dk) is obtained from the Chi-Square table with probability (1-α) and dk = (k- 1). On the other hand, if the result is x^2 count ≤ x^2 table with x^2 table = x^2 (1-α) (k-1) then the data is homogeneous (Sudjana, 1992).

3.2.2Variance Homogeneity Test

To test the similarity of several averages, as in the method of analysis of variance (ANOVA), it is assumed that the population has a homogeneous variance, namely yaitu $a_1^2 = a_2^2 = \ldots = a_k^2$ so it is necessary to test the homogeneity (similarity) of the normal population variance. From k (k >2) the population has independent and normal distribution, each with variance. $\alpha 1^2, a2^2, \ldots, ak^2$ Hypothesis will be tested:

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3.2.3Analysis of Variation (ANOVA)

ANOVA is a technique used to solve the total experimental variation into the observed sources. The total variation is composed in the components that make up the main factor or the interaction between factors.The critical area for optimization of phenol content (C6H6O) is determined by:

1. F tab (a-1), ab (n-1) for hypthesis $H0_1$
2. F tab (b-1), ab (n-1) for hypthesis $H0_2$
3. F tab (c-1), ab (n-1) for hypthesis $H0_3$
4. F tab (d-1), ab (n-1) for hypthesis $H0_4$

3.2.4Signal to Noise Ratio (SNR)

In analyzing the results, firstly the effect of the average standard deviation and the effect of the mean (SNR) of the experimental data are calculated. To find the average value of the data using the following formula: Taguchi introduced the SNR approach to examine the effect of the noise factor on the resulting variation. The type of SNR depends on the desired characteristics, namely:

1. Smaller the better
   Quality characteristics where the lower the value, the better is the water content
   The SNR values for this characteristic are:
   $SNR = -10 \log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{yi^2}\right)$
   with: n = number of repetitions in each experiment
2. Larger the better
   The quality characteristic where the greater the value, the better the quality is the phenol content.
   The SNR values for this characteristic are:
   $SNR = 10 \log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{yi^2}\right)$

Table 3.1. Phenol Compound Yield (%) On GC-M

Trial	Replication	Component	%
1	1	Phenol	**1,20**
2	1	Phenol	**1,50**
3	1	Phenol	**2,90**
4	1	Phenol	**4,10**
5	1	Phenol	**4,70**
6	1	Phenol	**9,10**
7	1	Phenol	**14,29**
8	1	Phenol	**15,95**
9	1	Phenol	**28,17**

Trial	Replication	Component	%
1	2	Phenol	**1,00**
2	2	Phenol	**1,7**
3	2	Phenol	**2,10**
4	2	Phenol	**4,3**
5	2	Phenol	**6,28**
6	2	Phenol	**7,60**
7	2	Phenol	**12,46**
8	2	Phenol	**14,48**
9	**2**	**Phenol**	**19,80**

3.3. Phenol Level Normality Test

Based on the data from the normality measurement of phenol levels listed in Table 3.2. get value:

k = 1+3, 32 log 18 = 5
R = 27,10
P = R/k = 5,43
$\sum (\sigma^2)$ = 55,59 = 7,48
μ= 9,45

Table 3.2. Phenol Level Normality Test

Class Limit	Upper Limit	Lower Limit	Oi	Ei
1,00 - 6,43	6,43	1,00	10	3,87
6,43 - 11,86	11,86	6,43	2	5,05
11,86 - 17,30	17,30	11,86	3	4,09
17,30 - 22,73	22,73	17,30	2	1,97
22,73 - 28,17	28,17	22,73	1	0,57
Total			18	15,57

Table 3.3. Combained

Combined				
Oi	Ei	Oi-ei	$(Oi-ei)^2$	$(Oi-ei)^2/ei$
10	4,79	5,20	27,11	5,65
8	11,68	-3,69	13,61	1,16
			X^2 hitung	6,81
			X^2 tabel	9,48

Table 3.4. Phenol Level Homogeneity Test

Rep	N-1	1/N-1	Si^2	(N-1) Si^2	log Si^2	(N-1) log Si^2
1	8	0,12	71,65	573,20	1,85	14,84
2	8	0,12	37,85	302,87	1,58	12,62
$\sum$	16		109,51	876,08	3,43	27,47

Calculating the combined variance of all samples (S^2)

$S^2 = [\sum(ni - 1)Si^2/\sum(ni - 1)]$
$S^2 = 876,08 \div 16 = 54,75$

Calculating unit price B

$B = (\log S^2).\sum(n - 1)$ (log 54,75) = 1,74
B = 1,74 x 16
B = 27,81

Count X^2

$X^2 = (In\ 10)[B - \sum(n_1 - 1) \log S_1^2]$
X^2 = 2,30 x (27,81– 27,46) = 0,80

The calculated value of the Barlett Test from the measurement of phenol content compared to the table value is as follows:

X^2 count = 0,80 while the value of X^2 table (0,95 : 8) = 15,51, because X^2 count $\leq X^2$ table that is 0,80$\leq$ 15,51 then Ho is accepted, which means that the data from the Barlett Test of homogeneous phenol levels.

3.4. Analysis of Phenol Variance

Table 3.5. Analysis of Phenol Variance

Faktor	SS	Df	MS	F Count	F Table	P Value (%)	SS'	Decision P value < α
A	2.860,09	1	2.860,09	19,69	4,60	275,45	2714,88	There is influence
B	1.464,66	1	1.464,66	9,91	4,60	133,61	1316,87	There is influence
C	1.094,52	1	1.094,52	7,40	4,60	96,05	946,73	There is influence
D	1.348,30	1	1.348,30	9,12	4,60	121,80	1200,51	There is influence
Error	6.731,52	13	145,21					
SST	985,59	17						
Total	13.463,05	1						

Based on the four control factors above, namely factors A, B, C, and D, each has an F count of 19.69; 9.91; 7.40; and 9.12, factors A, B C, and D have an effect on the response variable, because F count < F table.

3.5. Calculation of Signal to Noise Ratio (SNR) Phenol Level Data

Table 3.6. Phenol Level SNR Data

Trial	Faktor Kendali				Replikasi Ke		SNR
	1	2	3	4	1	2	
1	1	1	1	1	1,20	1,00	0,72
2	1	2	2	2	1,50	1,70	4,03
3	1	3	3	3	2,90	2,10	6,29
4	2	1	2	3	4,10	4,30	9,26
5	2	2	3	1	4,70	6,28	10,44
6	2	3	1	2	9,10	7,60	18,32
7	3	1	3	1	14,20	12,46	23,49
8	3	2	1	2	15,90	14,48	23,49
9	3	3	2	3	28,10	19,80	27,18

From the calculation of the effect of SNR on phenol levels, it is clear in table 4.14 that the influence or formation of phenol levels is the pyrolysis/combustion temperature where the higher the temperature used, the higher the phenol content and for drying time factors, condenser temperature, and burning time have no effect to phenol.

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

From the experiments that have been carried out on coconut shell liquid smoke products by considering 4 control factors, 3 levels and 2 experiments based on 2 response variables, the following conclusions were obtained:

1. Judging from the Anova table and the SNR Effect, the factors that affect phenol for rank 1 (A3) (pyrolysis temperature $180^0 \leq T \leq 102^0$) are used, rank 2 (B3) (pyrolysis time 5 hours), rank 3 (D2) (long drying time). shell 2 days) and rank 4 (C1) (condensation temperature 30^0).
2. For the target product shell liquid smoke containing phenol has an effectiveness comparable to 70% alcohol to be used as a disinfectant at a concentration of 12.5% and is safe to be used as a disinfectant in the

standard process (A3) (pyrolysis temperature $180^0 \leq T \leq 102^0$), (B1) (pyrolysis time 1 hour), (C3) (condensation temperature 40^0) and (D1) (shell drying time 0 days).

4.2 Suggestion

1. Based on the results of experiments that have been carried out, it can improve the quality of coconut shell liquid smoke as an organic disinfectant based on phenol, so it is better to pay more attention to the pyrolysis/combustion temperature because temperature greatly affects the quality of shell liquid smoke.
2. It is necessary to use different raw materials other than wood, rice husks, corn cobs, astiri leaves, and coconut shells in the manufacture of liquid smoke which contains a lot of phenolic compounds.
3. It is necessary to use it as a type of bacteria test.

References

Erlytasari, D., N., Wibisono, G., Hapsari, R. (2019). Efektivitas Asap cair Berbagai Konsentrasi Sebagai Disinfektan Alat Klinik Gigi, *Jurnal Kedokteran Diponegoro*, Vol. 8, No. 4, pp. 1114-1123.

Guillen, Maria, D., Maria, J., Manzanos., Maria, L., Ibargiotia. (2001). Carbohydrate and Nitrogenated Compounds in Liquid Smoke Flavorings, *Journal of Agricultural and Food Chemistry*. Vol. 49, No. 5, pp. 2395-2403.

Hayati, N. (2018). Optimasi Kondisi Pirolisis Dan Pengeringan Pada Proksimat Arang Tempurung Kelapa Dengan Metode Taguchi, *Jurnal Simetris*. Vo1. 2, No. 1, pp. 1-6.

Karseno, Darmadji, P., Rahayu, K. (2001). Daya Hambat Asap Cair Kayu Karet Terhadap Bakteri Pengkotaminan Lateks Dan Ribbed Smoke Sheet, *Agritech*, Vol. 21, No. 1, pp. 10-15.

Kilinc, B., & Cakli, S. (2012). Growth of Listeria Monocytogenes as Affected by Thermal Treatments of Rainbow Trout Fillets Prepared With Liquid Smoke, *Turkish Journal of Fisheries and Aquatic Sciences*. Vol. 12, No. 2, pp. 285-290.

Nugroho, A., & Aisyah, I. (2013). Efektivitas Asap Cair Limbah Tempurung Kelapa Sebagai Biopestisida Di Gudang Penyimpanan. Jurnal Penelitian Hasil Hutan. Vol. 31, No. 1, pp. 1-8.

Peace, G., S. (1993). *Taguchi Methods A Hands-on Approach*. Addison Wesley Publishing Company. Canada.

Sudjana, (1992). Metoda Statistika. Tarsito. Bandung.