

THE EFFECTIVENESS OF LIQUID SMOKE PRODUCED FROM PALM KERNEL SHELLS PYROLYSIS AS A NATURAL PRESERVATIVE IN FISH BALLS

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ABSTRACT: This study investigated the utilization of liquid smoke as a natural preservative in fish balls without reducing their nutrition and aesthetic value. The liquid smoke used in this research was obtained through pyrolysis of palm kernel shells at temperatures of 340, 360, and 380°C. The resulting liquid smoke was then purified using a two-stage distillation process at a temperature of 200°C in order to remove unwanted compounds. This grade-1 liquid smoke was then used to preserve fish balls. The parameters assessed to monitor the fish balls' preservation were total volatile bases (TVB), pH, and organoleptic test results. The results showed that the smallest TVB value of 12.66 mgN/100 g at 20 hours was obtained for fish balls preserved using liquid smoke pyrolysis at 380°C (3% concentration). The organoleptic test showed that 90% of respondents preferred the taste, aroma, and texture of the fish balls preserved using liquid smoke pyrolysis at a temperature of 340°C (2% concentration). The pH test showed that the fish balls preserved using liquid smoke possessed a pH above 6, meaning that they were in good condition.

Keywords: *Palm Kernel Shells, Liquid Smoke, Fish Balls, Organoleptic Test, Total Volatile Bases*

1. INTRODUCTION

One of the major developing industries in Indonesia is processing of the oil palm, of which Indonesia currently has the largest plantation area in the world as well as being the largest crude palm oil (CPO) exporter. This industry results in not only CPO but also abundant side products, namely empty bunches, branches, kernel shells, and fronds. Failure to utilize this waste will lead to environmental problems owing to its abundance and the fact that it requires a long time to degrade.

Oil palm waste, especially which from kernel shells, is often used as fuel in boilers to produce steam, as road filler, or simply discarded as trash. Its high content of lignin, hemicelluloses, and lignin cellulose gives it the potential to be developed into raw materials for producing liquid smoke: the liquid resulting from condensing smoke from the pyrolysis of materials that contain wood components such as cellulose, hemicellulose, and lignin. These three components strongly determine the quality of the resulting liquid smoke [1]–[4]. It has been reported that palm kernel shells contain 27.7% cellulose, 21.6% hemicelluloses, and 44% lignin [1]. In addition to liquid smoke, the charcoal that also results from pyrolysis can be utilized as activated charcoal [5], [6].

People commonly employ a slow pyrolysis process to produce a volatile compound, which is then condensed into liquid smoke. The liquid smoke obtained from wood biomass typically

contains a mixture of oxidized organic compounds such as ketones, aldehydes, phenols, and carboxylic acids [7], [8]. These compounds possess antimicrobial and antioxidative properties that can be used against streptococcus bacteria in the mouth [9]. Such antimicrobial properties can inhibit harmful microbial activities that can rot food, hence prolonging the food's storage life. In addition, liquid smoke can also affect the taste, color, and particular aroma [10], [11] of food. Liquid smoke resulting from corn cobs, rice hulls, peanut shells, coconut shells, coconut fiber, mangroves, pines, etc., contains phenol and offers antibacterial properties that can preserve and add flavor to food products [12]–[14]. Zuraida et al. [15] studied the antibacterial activity of coconut shell liquid smoke in proteinaceous food products and its application in fish ball preservation. Liquid smoke as a preservative is best suited to processed meat items such as hot dogs, sausages, ham, and bacon [16]. Meanwhile, the liquid smoke of grade 2 has been used as a biopesticide to inhibit the growth of *Colletotrichum capsici* fungi, which causes fruit rotting in chili plants [7].

The use of dangerous preservatives such as formalin and borax by food producers has become rampant recently. Prolonged use of these dangerous substances can cause cancer. Other substances typically used as food preservatives include nitrates, benzoates, sulfites, sorbates, aldehydes, and others that cause side effects such as carcinogenic effects, abdominal pains, and

chronic inflammation in the stomach and intestines, which could lead to death [17]–[19]. This signifies the need to develop inexpensive and safe natural preservatives [20]. A previous study demonstrated the ability of liquid smoke to preserve tofu and indicated that liquid smoke can prolong the storage life of smoked products by up to two days [21].

Fish balls are a popular food in Indonesia, so the widespread use of formalin and borax to preserve them causes consumers concern. Excessive addition of formalin and borax can be toxic and endangers human health. This research is aimed at identifying the ability of liquid smoke to work as a natural preservative in fish balls. The parameters used to monitor fish ball preservation were TVB, organoleptic testing (color, aroma, taste, and texture), and pH. Liquid smoke as a natural preservative is expected to replace commonly used artificial preservatives.

2. MATERIALS AND METHODS

2.1 Producing Liquid Smoke

As much as 6 kg of palm kernel shells were placed into a stainless steel pyrolysis reactor ± 30 cm in diameter and ± 50 cm in height. The temperatures used in this pyrolysis were 340, 360, and 380°C. The smoke emitted from the reactor was then condensed to produce grade-3 liquid smoke, tar, and charcoal. Subsequently, the grade-3 liquid smoke was purified by distillation at a temperature of 180–200°C to produce grade-1 liquid smoke. A schematic diagram of the pyrolysis is shown in Figure 1. Finally, the resulting liquid smoke was used to preserve fish balls at concentrations of 1%, 2%, and 3%.

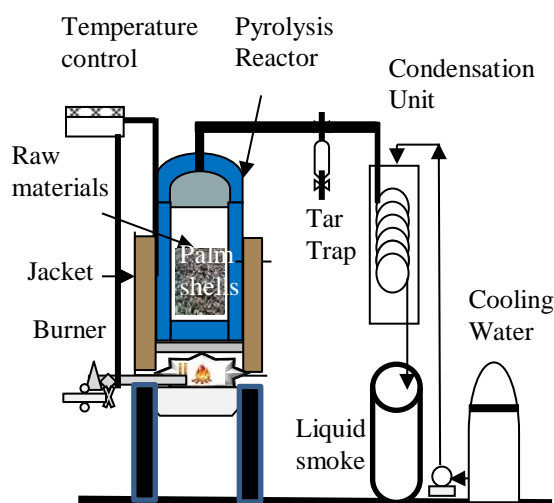


Fig. 1 Schematic diagram of liquid smoke preparation

2.2 Fish Ball Preservation

Fish ball preservation is performed by soaking fish balls in liquid smoke for 15 minutes and then draining them. The TVB, pH, and organoleptic analyses were performed every five hours.

2.3 Total Volatile Bases (TVB) Test

The TVB test was based on an Indonesian national standard procedure performed on 2 g of ground fish ball samples. The samples were blended with 75 ml of 7% trichloroacetic acid (TCA) solution for 1 min before being filtered and tested for TVB. The next step involved a Conway dish containing 1 ml of boric acid in its inner chamber and the sample filtrate in its outer chamber. The dish was then covered, and 1 ml of K_2CO_3 solution was added to its outer chamber. For the blank solution, drips of 5% TCA were added to the filtrate. The sample was then incubated at 35°C for two hours. Afterwards, the inner chamber of the Conway dish (both the blank and the sample) was titrated using 0.02 N HCl until it turned pink. The TVB value was calculated using equation 1.

$$\text{TVB (mgN\%)} = ((V_{\text{sample}} - V_{\text{blanko}}) \times 14.007 \times 100) / \text{Sample weight} \dots\dots\dots (1)$$

2.4 Organoleptic Test

The organoleptic test depends on physical senses, namely based on the tongue (taste), eyes (color), and nose (smell). The resulting reactions signify preferences and dislike for the stimulants. This organoleptic test was conducted with the help of a panel consisting of 20 people.

3. RESULTS AND DISCUSSION

3.1 Liquid Smoke Chemical Contents

Liquid smoke resulting from palm kernel shells at different temperatures has different compositions [22], [23]. Assessment of the chemical content in the liquid smoke was performed using Pyro-GCMS (GCMS-QP2010, SHIMADZU) based on a method developed by Guillen and Ibargoitia [10], [24]. These GC-MS test results showed that the resulting liquid smoke contained acetic acid, phenol, and other components. They also showed that the liquid smoke did not contain any harmful compounds. The complete results for liquid smoke pyrolyzed at a temperature of 340°C can be seen in Table 1.

Table 1 Chemical composition of liquid smoke pyrolyzed at 340°C

No	Residence Time	Area	%	Name
1	3,449	1137 5657	0.56	2-Propanone (CAS) Acetone
2	3,621	1978 8929	0.98	Acetic acid, methyl ester (CAS) Methyl acetate
3	3,850	9696 220	0.48	2-Propen-1-ol (CAS) Allyl alcohol
4	4,272	4314 136	0.21	2-Butanone (CAS) Methyl ethyl ketone
5	5,304	5780 8325 8	28.4 9	Acetic acid (CAS) Ethylic acid
6	5,572	1929 5921 4	9.51	2-Propanone, 1-hydroxy- (CAS) Acetol
7	5,892	6626 9576	3.27	Hydroxylamine, O,O'- 1,2-ethanediybis-
8	6,249	2345 4804 2	11.5 6	Acetic acid (CAS) Ethylic acid
9	7,152	2709 4894	1.34	Propanoic acid (CAS) Propionic acid
10	7,904	6051 736	0.30	3-Pentanone (CAS) Diethyl ketone
11	9,508	3306 6485	1.63	2-Furancarboxaldehyde (CAS) Furfural
12	10,350	2989 193	0.15	2-Propanol, 1-amino- (CAS) 1-Amino-2- propanol
13	10,533	3012 268	0.15	2-D-2-Pentadecyl-1,3- Dioxolane
14	12,332	4042 6603 6	19.9 2	2-D-2-Pentadecyl-1,3- Dioxolane
15	12,788	1552 6392 5	7.65	Benzenesulfonic acid, 4- hydroxy- (CAS) Benzenesulfonic acid, p- hydroxy-
16	13,293	5139 6218	2.53	Phenol, 2-methyl- (CAS) o-Cresol
17	13,583	5088 8518	2.51	Phenol, 2-methoxy- (CAS) Guaiacol
18	13,756	6376 0822	3.14	Phenol, 3-methyl- (CAS) m-Cresol
19	14,375	4663 989	0.23	2-Methoxy-4- methylphenol
20	14,550	4222 348	0.21	2-Methoxy-4- methylphenol
21	14,635	4348 171	0.21	2-Methoxy-4- methylphenol
22	14,862	1273 2670	0.63	2-Methoxy-4- methylphenol
23	17,219	7820 732	0.39	Phenol, 2,6-dimethoxy- (CAS) 2,6- Dimethoxyphenol

The GC-MS results specifically showed that liquid smoke produced from palm kernel shells at 340°C with a two-stage distillation process contains 41.03% acetic acid, 8.18% phenol, and 50.79% other compounds. Various phenolic compounds in liquid smoke lower the pH and destroy bacterial cell walls [25].

3.2 TVB Test

TVB testing is one way to determine the

quality of food ingredients. Research by Fraser and Sumar [26] stated that bacterial metabolism in food results in accumulating ammonia and other volatile alkaline species. It has been reported that several types of food can be categorized as unfit for consumption when their TVB values are higher than 30 mg N/100 g of the sample [27]. However, our research showed that even at a TVB value of 20 mg N/100 g of sample, fish balls were already unfit for consumption, as they then presented a slimy texture and changes in taste. The TVB test process performed on the fish balls after being preserved by liquid smoke is shown in Figure 2.

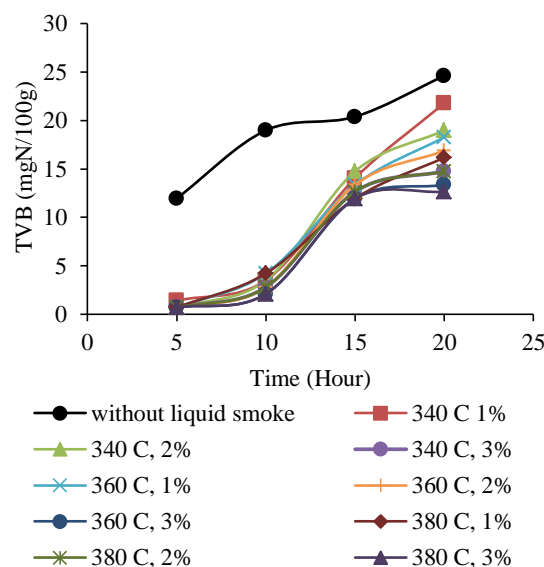


Fig. 2 Changes in TVB values over time

Changes in TVB values over time (Figure 2) showed that the samples preserved with liquid smoke at a temperature of 380°C and 3% concentration had the lowest TVB value of 12.6 mg N/100 g of sample. In the first 15 hours, changes in the pyrolysis temperature when producing liquid smoke did not have a significant influence on the TVB values. However, after 20 hours of storage, the pyrolysis temperature influenced TVB values. Changes in TVB values are influenced by the strength of the preservatives used to inhibit decay-causing bacteria from disintegrating proteins in the food into ammonia and other volatile alkaline species. Liquid smoke can perform such inhibition owing its antioxidant and antibacterial properties. Previous research showed that liquid smoke used to preserve tofu can prolong its storage life from 2 days to ± 4 days [21].

3.3 Organoleptic Test

Organoleptic testing is crucial for all food

products because of its relevance to consumer acceptance. The test is performed in this research to assess the panelists' preferences for color, aroma, texture, and taste of preserved fish balls.

3.3.1 Color

Color or appearance are visual attributes that catch consumers' attention before the other attributes of a product. Color can indicate chemical changes in food and is, therefore, an important factor in the acceptance of a certain food product. Delicious and highly nutritious food with a good texture but unacceptable color may be less favored by consumers. The results of the color tests are shown in Table 2.

Table 2 shows that soaking fish balls in a 2% concentration of liquid smoke gives them a clean, light cream color. Our questionnaire recorded that all 20 panelists showed a preference for clean, light-cream-colored fish balls that do not appear pale. Consumers are more interested in a food product if its color is appealing and does not differ much from its normal color.

Table 2 Color test results for fish balls

Pyrolysis Temp. (°C)	Liquid Smoke Conc.	Color			
		5 hours	10 hours	15 hours	20 hours
340	1%	4	4	4	2
	2%	4	4	4	2
	3%	4	4	2	3
360	1%	4	4	3	2
	2%	4	4	3	3
	3%	4	3	3	2
380	1%	4	3	3	2
	2%	4	3	3	4
	3%	4	3	3	4
Without liquid smoke		4	3	3	1

Remarks:

Brown=1; light brown=2; cream=3; light cream=4; dark brown=5.

3.3.2 Taste and aroma

Aroma is a nose response due to the evaporation of particularly recognizable soluble substances from a food product into the air. The stimulation caused by an ingested food product is mostly represented by taste and smell. Taste and aroma are crucial parts of testing in the food industry because they provide direct assessment of consumers' preferences. The results of such testing on fish balls are displayed in Table 3.

Table 3 shows that many of the panelists preferred fish balls preserved in a 1% concentration of liquid smoke resulting from a

pyrolysis temperature of 340°C.

Table 3 Testing of taste and aroma in fish balls

Pyrolysis Temp. (°C)	Liquid Smoke Conc.	Taste and Aroma			
		5 hours	10 hours	15 hours	20 hours
340	1%	1	1	1	1
	2%	1	1	5	3
	3%	1	5	5	3
360	1%	1	1	5	3
	2%	1	1	5	3
	3%	5	5	5	3
380	1%	1	1	3	3
	2%	3	3	3	3
	3%	3	3	3	3
Without liquid smoke		2	2	4	4

Remarks:

1=delicious and has a smoky aroma; 2=delicious and has no smoky aroma; 3=not delicious and has a smoky aroma; 4=not delicious and has no smoky aroma; 5=taste is fair and has a smoky aroma.

The resulting fish balls have a smoky aroma, natural taste, and are not acidic. The smoky aroma of the fish balls arises from the liquid smoke absorbed onto the fish balls' surface. An unpleasant aroma can indicate damage to the products caused by inappropriate production processes and storage. The number of acids in liquid smoke might affect the flavor, color, texture, and microbial stability of food [28]. Acetic acid is the most dominant organic acid in liquid smoke, followed by propionic, formic, butyric acids [29].

3.3.3 Texture

Texture assessment was performed using the mouth and/or hands with the purpose of feeling the texture of a food product. The test results are displayed in Table 4.

Table 4 Texture assessment results on fish balls

Pyrolysis Temp. (°C)	Liquid Smoke Conc.	Texture			
		5 hours	10 hours	15 hours	20 hours
340	1%	4	4	2	2
	2%	4	4	2	2
	3%	4	4	2	2
360	1%	4	1	1	1
	2%	4	1	1	2
	3%	4	1	1	2
380	1%	4	1	1	2
	2%	4	1	2	2
	3%	4	1	2	2
Without liquid smoke		4	1	2	2

Remarks:

1=Quite hard; 2=stiff; 3=slightly stiff; 4=soft.

Table 4 shows that soaking in a 1%, 2%, or 3% liquid smoke solution produced at a pyrolysis

temperature of 340°C resulted in soft-textured fish balls compared to using liquid smoke produced at other pyrolysis temperatures, which resulted in hard textures. Consumers generally prefer soft textures since hard and chewy textures are often associated with the use of dangerous preservatives in food products.

4. CONCLUSION

Liquid smoke produced from pyrolysis of palm kernel shells could be used as an alternative preservative for fish balls. Liquid smoke concentration and pyrolysis temperature affect the storability of fish balls. TVB values decreased with increasing pyrolysis temperature. Results show that fish balls soaked in liquid smoke produced at a pyrolysis temperature of 380°C resulted in the smallest TVB value of 12.66 mgN/100 g of sample in 20 hours. Nevertheless, fish balls soaked in liquid smoke produced at a pyrolysis temperature of 340°C with a 2% concentration were preferred by 90% of respondents in terms of taste, aroma, and texture.

5. ACKNOWLEDGEMENTS

This work was funded by Syiah Kuala University, the Ministry of Research, Technology and Higher Education of Indonesia under research grand No. 1712/UN11/SP/PNBP/2016.

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