RESEARCH ARTICLE | MAY 30 2023

# Application of liquid smoke from pyrolysis byproducts of ulin wood sawdust (*Eusideroxylon Zwageri*) as a preservative of mackerel (*Rastrelliger*)

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*AIP Conference Proceedings* 2596, 040004 (2023)
https://doi.org/10.1063/5.0118742

# Application of Liquid Smoke from Pyrolysis Byproducts of Ulin Wood Sawdust (*Eusideroxylon zwageri*) as a Preservative of Mackerel (*Rastrelliger*)

Takdir Syarif[1,a)], Andi Aladin[2,b)], Basri Modding[2,c)], Lastri Wiyani[2,d)], and Fransisca Christiana Dewi[3,e)]

[1]*Chemical Engineering, Faculty of Industrial Technology, Indonesian Muslim University, Makassar-Indonesia*
[2]*Management, Faculty of Economics, Indonesian Muslim University, Makassar-Indonesia*
[3]*Agricultural, Petra Baliem Wamena College of Agricultural Sciences, Wamena-Indonesia*

[a)] takdir.syarif@umi.ac.id
[b)] Corresponding author: andi.aladin@umi.ac.id
[c)] basri.modding@umi.ac.id
[d)] lastri.wiyani@umi.ac.id
[e)] franciesca.christ11@gmail.com

**Abstract.** Carbon-based agricultural waste such as sawdust waste or red fruit seed waste can be processed into carbonized charcoal (charcoal) as the main product and liquid smoke as a byproduct in a pyrolysis reactor. The liquid smoke product can be used as a food preservative such as fish preservatives, as an alternative to the conventional method, namely smoking fish directly over smoke and coals, which have a carcinogenic effect. In this study, the simultaneous pyrolysis of ulin wood sawdust (*Eusideroxylon Zwageri)* was carried out at a pyrolysis temperature of 400 ºC and a pyrolysis time of 2 hours. The byproduct of pyrolysis in the form of grade 3 liquid smoke is distilled twice to obtain grade 1 liquid smoke-free from benzopyrene compounds (cancer triggers). Grade 1 liquid smoke was diluted to 5% and then tested as a preservative for mackerel (rastrelliger). From this study, the maximum shelf life of fish is three days in an open space with organoleptic properties, including aroma and texture that are only one level lower than fresh fish (1-hour shelf life). The aroma of pickled fish tastes like smoked fish but is a bit fishy (scale 4 out of a scale of 1-5). The texture is a bit soft (scale 4) compared to the control fish (without preservation of liquid smoke). All of the textures are almost destroyed (scale 1.25-1.5).

## INTRODUCTION

Ulin wood (*Eusideroxylon zwageri* T. et B.) is one of the native plants of Indonesia that can be found on the island of Borneo. It has high quality, especially strength and resistance to various natural conditions, weathering, and attacks by wood-destroying organisms. Ulin wood is very hard, classified into durable class I and strong class I in Indonesia. Ulin wood is composed of 58.1% cellulose, 28.9% lignin, 12.7% pentosan, 1% ash, and 0.5% silica [1,2]. Ulin wood is also known as ironwood. Based on the special characteristic of ulin wood, ulin wood was chosen as the main material in the phinisi boat manufacturing industry in the Bulukumba area, South Sulawesi. This industry produces the main waste in the form of sawdust which is quite large but is not utilized so that it damages the aesthetics of the environment and is even allowed to drift into the sea. Considering the chemical composition of ironwood is dominated by cellulose and lignin, ulin wood sawdust can be processed by pyrolysis to produce charcoal which can be used as solid fuel with a calorific value equivalent to coal. Using a simultaneous pyrolysis reactor and producing the main product, charcoal produces grade 3 liquid smoke byproducts.

In general, pyrolysis is defined as the process of degradation of macromolecular compounds by heating at high temperatures without or minimal oxygen to produce charcoal, liquid smoke, and gas. The pyrolysis temperature of biomass ranges from 350 – 550 ºC. It sometimes reaches up to 700 ºC depending on the type and complexity of the

*Proceedings of the 1st Unhas International Conference on Agricultural Technology (UICAT 2021)*
AIP Conf. Proc. 2596, 040004-1–040004-6; https://doi.org/10.1063/5.0118742
Published by AIP Publishing. 978-0-7354-4429-4/$30.00

chemical content of the material to be pyrolyzed and depending on the desired final pyrolysis product [3]. During the pyrolysis process, most of the water content and the volatile matter will be released along with the degradation products of cellulose, hemicellulose, and lignin macromolecular compounds from biomass materials collectively referred to as smoke. This smoke can be condensed to form liquid smoke grade 3, which has economic value. The gaseous products of the micro compounds resulting from the degradation are carboxylic acid compounds (such as oxopentanic acid, acetic acid, benzoic acid, formic acid, glycolic acid, hexadecanoic acid, hexanoic acid, propanoic acid, valeric acid), ketone compounds (such as 1-hydroxy 2- propanone, 2,5 hexanedione, 2-butanone, 2-ethylcyclopentanone, 2-methyl2-cyclopenten-1-one), phenolic compounds and their derivatives, benzopyrene, oxygenates such as furans and other hydrocarbons. The content of these acid compounds, ketones, and phenols is antibacterial, and therefore liquid smoke allows it to be used as a food preservative. The most identified chemical compounds in Liquid Volatile Matter (LVM) are phenolic compounds, carbonyls, carboxylic acids, furans, hydrocarbons, alcohols, and lactones. Aladin et al. [4] wrote the idea of Pyrolysis of Corncob Waste to Produce Liquid Smoke. The idea was then realized in innovation through research on Simultaneous Pyrolysis Reactor Designs. This simultaneous pyrolysis reactor can produce around 55% charcoal products and grade 3 liquid smoke about 40% of the weight of coconut shell biomass waste raw materials[3].

Preservation of foodstuffs still often uses harmful chemicals such as fish preservation using formalin, so the alternative is to use liquid smoke. The content of chemical compounds in liquid smoke, such as derivatives of phenol compounds, carbonyl, antibacterial acids, and antioxidants, can preserve fish and provide a distinctive aroma and taste that can stimulate the appetite. At ten times dilution, liquid smoke was still able to inhibit the growth of *Pseudomonas fluorescence*, *Bacillus subtilis, Escherichia coli*, and *Staphylococcus aureus* bacteria [5]. The antioxidant role is shown by high boiling phenol compounds, especially 2,6-dimethoxyphenol; 2,6-dimethoxy-4-methylphenol, and 2,6-dimethoxy-4-ethylphenol, which act as hydrogen donors to free radicals and inhibit chain reactions. These compounds can inhibit fat oxidation, prevent lipid oxidation by stabilizing free radicals, and effectively prevent loss of taste due to fat oxidation [5].

Traditionally, fishing communities used coconut shells or other wood fuels as fuel for smoking fish directly to preserve fish and give smoked fish a distinctive taste that can arouse appetite. However, this smoke is not sterile from carcinogenic compounds such as benzopyrene, so there is a risk of side effects (cancer). A healthier alternative to fish preservation is indirect smoking using liquid smokepyrolysis of biomass materials such as coconut shells and corn cobs. Grade 1 liquid smoke can be used as a food preservative because it contains antibacterial and antioxidant compounds but is sterile from carcinogenic substances such as benzopyrene. At the same time, the distinctive aroma and taste of smoked fish remain as indirect smoke [4,6,7].

Liquid smoke can provide a distinctive smoke flavor, similar to the aroma of direct smoking. The formation of aroma in the smoking product is obtained due to the presence of phenolic compounds with a medium point. Smoking fish using liquid smoke gives a better color, a light golden brown color, than smoking directly over coals [5]. Another advantage of grade 3 liquid smoke is that after a repeated distillation process at 98-100 °C, the liquid smoke is guaranteed to be clean of benzopyrene content (boiling temperature 300 °C) carcinogenic, as previous researchers have carried out laboratory tests. The carcinogenic content cannot be avoided in smoking fish directly over coals and fire smoke [8]. Grade 1 liquid smoke from coconut shells and corn cobs has proven effective food preservatives. Aladin et al. [9] have researched the use of grade 1 liquid smoke from coconut shells as a preservative for mackarel fish. Aladin et al. [10] have also researched the use of grade 1 liquid smoke from corn cobs as a preservative for katombong fish.

Indonesia is also known as a maritime country with a sea area larger than its land area, which is a country that produces a variety of fish. One type of fish widely consumed by the Indonesian occupation is mackerel. The Bugis-Makassar name for mackerel is katombong fish, while the scientific name is rastrelliger. Mackerel in Indonesia occupies the second-highest position in the volume of capture fisheries production after flying fish. The high volume of capture fisheries production requires fishers to maintain the durability and quality of the fish to last a long time. One method of preserving fish is the smoking method, either direct smoke or immersion in a liquid smoke solution. Therefore, it is important to know the application of liquid smoke from pyrolysis of ulin wood sawdust as a preservative from mackerel.

## RESEARCH METHODS

Grade 3 liquid smoke is a byproduct of pyrolysis of ulin wood sawdust from industrial waste from phinisi boats in Bulukumba (South Sulawesi) with pyrolysis operating conditions the optimum time of 3 hours and the optimum

temperature of 400 ºC [4]. The grade 3 liquid smoke is first purified from toxic and carcinogenic substances (benzopyrene) by distillation in a distillation flask (1) on a heating stove (2) which is equipped with a leibigh condenser (3) which is connected to an inlet cooling water hose (4). and the cooling water hose to the outside (5) and is equipped with a thermometer (6) and a distillate reservoir (erlenmeyer) (7) (Fig. 1). This distillation process is allowed to continue at a boiling temperature of liquid smoke around 98 ºC (first stage). It is stopped when the temperature of the liquid begins to rise (second stage), or the liquid smoke residue in the distillation flask appears to be getting a bit thick. The distillate liquid is accommodated in another container (8). This liquid is referred to as liquid smoke grade 2 with a clearer color than liquid smoke grade 3.

Fresh mackerel was purchased directly from the "Paotere" fisherman in Makassar city, with 12 fish with relatively uniform weight sizes. The fish are cleaned, the entrails removed, the tail and fins cut off, and then the weight of each one is weighed. The 10 fish from the 12 fish (2 fish as controls) were placed in a row in a 3-liter long rectangular tray soaking container. Grade 1 liquid smoke solution, which has been diluted to 5%, is poured into a 3-liter immersion container (lined with fish) to submerge the fish completely. After 5 minutes of soaking, the first pair of fish were separated from the immersion container and drained in a plastic basket for 10 minutes.

Similarly, after an immersion time of 10, 15, 20, and 30 minutes, the second to fifth pairs of fish are removed from the immersion container and drained in a plastic basket. All fish that had been drained together with a pair of control fish (without soaking in liquid smoke) was then stored in a clean, sterile room and free from disturbance from animals or insects such as flies and ants for observation every time for up to 3 days. Observations were made in the first hour and 48 hours (2 days) in the form of organoleptic observations, namely aroma (A) and texture (T), with a scale value of 1-5 (Table 1). Organoleptic test using a panel of 50 healthy adults. Panelists are people who are involved in a series of product testing and act as tools or instruments in organoleptic testing. Panelists assess product quality and analyze the sensory properties or attributes of the products they test based on subjective impressions.

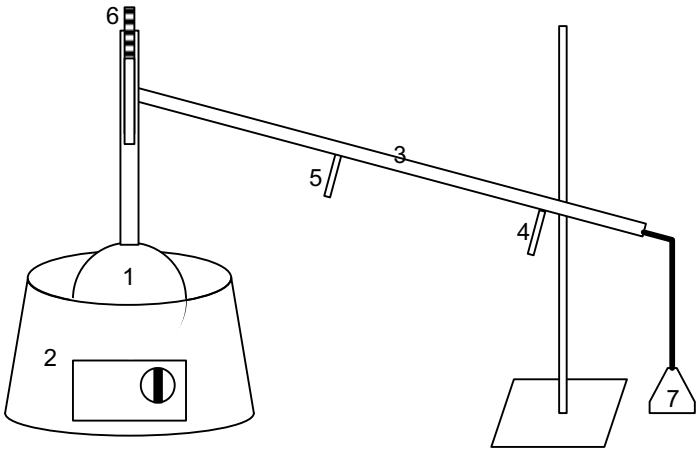


**FIGURE 1.** Distillation apparatus.

**TABLE 1.** Organoleptic Analysis Scale.

| Scale | Aroma (A) | Texture (T) |
|---|---|---|
| 1 | Very bad smell | Broken |
| 2 | Bad Smell | Very soft |
| 3 | Fishy smell | Soft |
| 4 | Rather Fishy smell | Rather soft |
| 5 | Fresh smell | Fresh texture |

## RESEARCH RESULTS AND DISCUSSION

### Storage Time 1 Hour

From the research, the effect of soaking mackerel in a 5% solution of grade 1 liquid smoke resulting from the pyrolysis of ironwood sawdust on the organoleptic properties in the first hour of storage can be seen in Fig. 2.

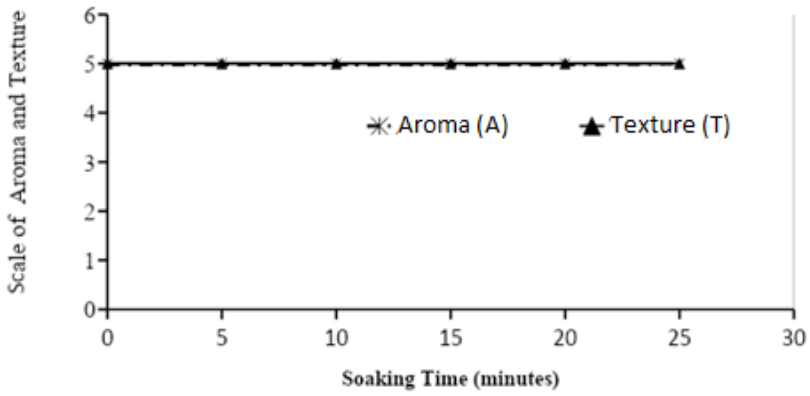


**FIGURE 2**. The Effect of Soaking Mackerel in Liquid Smoke on A Storage Period of 1 Hour.

In Fig. 2 it can be seen that the aroma of all fish is still fresh (scale 5), both for control fish and for fish soaked in the liquid smoke solution, the only difference is that for fish soaked in the liquid smoke solution, the aroma is fresh, typical of smoked fish. Other organoleptic properties, namely the texture of fish, are also normal (fresh/hard chewy, scale 5). Another phenomenon observed directly by the researchers (not through the panelists in the organoleptic test) was color. When mackerel was immersed in a 5% concentration of liquid smoke, there was an immediate color change. The eye of the fish immediately appeared white. Compared to the eye of the control fish, the color remained still normal (clean black). The color of the fish soaked in the liquid smoke solution appeared slightly pale in the first hour after immersion. Compared to the control fish, the color was still very fresh, typical of mackerel. The color change of this sensitive fish is due to the chemical influence of liquid smoke, which contains acid with an indication of a fairly low pH of around 2-3.

### Storage Time 72 hours

The results of the observation of the effect of immersion time on the organoleptic properties of fish during 72 hours (3 days) storage are presented in Fig. 3. In the figure, it appears that the aroma of the control fish (without soaking in liquid smoke solution) is rotten (1.25 scale), so it is not feasible for consumption. Likewise, the texture of the control fish was very soft, almost destroyed (scale 1.5).

For fish soaked in a liquid smoke solution with an immersion time of 5 minutes which was stored for three days in an open space, the effect of preservation was seen as a pale color with a more fishy aroma (scale 3.25) and a slightly mushy texture (scale 3.5) where both This organoleptic parameter was much better than the control fish, namely the smell was more foul (scale 1.25) and the texture was almost crushed (scale 1.5). Determination of the pale color is based on direct observations of researchers by comparing the color of fresh fish and control fish.

For fish soaked for 10 minutes in a solution of liquid smoke and stored for three days in an open space, it gives a better preservation effect than that which is soaked for 5 minutes, the color is not too pale (3.5 scales), the aroma is not rotten only a little fishy (scale 4) and the texture is only slightly mushy (scale 4). Based on the organoleptic test, fish with a scale of 4 is still suitable for consumption, compared to a scale of 3 that is less suitable, and a scale of 2 and 1 is not suitable for consumption.

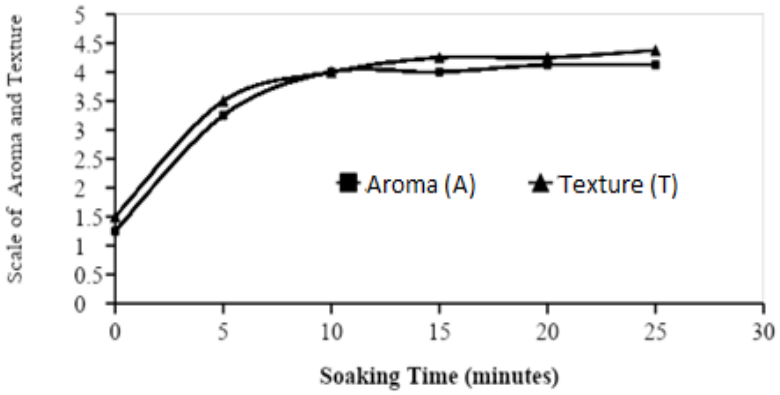


**FIGURE 3**. The Effect of Soaking Mackerel in Liquid Smoke on A Three-Day Storage Period.

As shown in Fig. 3, fish soaked in 5% liquid smoke with a soaking time of 15 and 20 minutes no longer provided a significant increase in preservation based on organoleptic tests compared to 10 minutes of immersion. This indicates that the preservative impregnation of grade 1 liquid smoke solution resulting from the pyrolysis of ironwood sawdust (concentration 5%) is saturated or optimal after 10 minutes of immersion.

## CONCLUSION

From the research on the use of grade 1 liquid smoke resulting from the pyrolysis of ironwood sawdust as a preservative for mackerel (rastrelliger), it can be concluded that the optimum soaking time or length of mackerel in a 5% solution of liquid smoke is 10 minutes which provides shelf life up to its shelf life in an open space in 3 days. Organoleptic properties of mackerel fish as a result of the preservation include a non-rotten aroma, only slightly fishy (scale 4), and a slightly mushy texture (scale 4) one level below the normal level of fresh fish (scale 5). Based on these organoleptic properties, the fish preserved with liquid smoke is suitable for consumption for up to 3 days in an open space.

## ACKNOWLEDGMENTS

Director of DRPM of the Ministry of Research and Technology/National Agency for Research and Innovation for the research costs of the Higher Education Leading Research (PUPT) scheme for 2019-2021

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