



# Quality Determination of Smoke Fish of The Dumbo Lele Type (*Clarias gariepinus*) by Conventional and Modern Methods

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**Abstract.** Fish is the perfect food ingredient that contains very high nutritional value, making it good for consumption, including catfish (*Clarias gariepinus*). The fish is known as a fast-food commodity that undergoes decay and cannot be stored for long. Processing with fogging makes the fish more durable. The purpose of this research is to understand the preservation process of catfish (*Clarias gariepinus*) through modern and conventional fogging methods and to assess the quality of the catfish using proximate analysis (water, ash, fat, and protein), pH, and formaldehyde. The research was conducted using conventional fogging by smoking the fish directly above the fire source and modern fogging by soaking the fish in a liquid smoke solution with a concentration of 50%. The results showed that the quality of the catfish (*Clarias gariepinus*) analyzed through proximate analysis (water, ash, fat, and protein), pH, and formaldehyde using modern fogging methods demonstrated higher quality compared to the conventional methods.

**Keywords:** Smoke Fish, *Clarias gariepinus*, Conventional and Modern Methods

## 1 Introduction

The number of freshwater aquaculture companies experienced a substantial fivefold increase in 2022 compared to 2021. There are 37 companies engaged in freshwater aquaculture and spread across several provinces in Indonesia. This significant increase reflects the development of the potential of freshwater aquaculture. Considering the condition of capture fisheries which is approaching overfishing [1]. The need for animal protein, especially those sourced from fish, contains very high nutritional value so it is good for consumption. One of the potential sources of animal protein fishery products and abundant in the market is dumbo catfish (*Clarias gariepinus*) [2].

Fish is known as a food commodity that spoils quickly. This is because fish is rich in protein and high water content as a medium for bacteria to grow, because of this nature fish cannot be stored for a long time. The activity of microorganisms that cause decay and oxidation reactions that cause a rancid odor so that one of the efforts is preservation to maintain shelf life and not damage the nutritional value contained in fish.

Smoking makes fish durable and allows it to be distributed from production centers to consumer centers, so it is necessary to conduct a study that examines the quality of smoked fish species of dumbo catfish (*Clarius garapianus*) through proximate analysis (water, ash, fat, protein), pH and formaldehyde with conventional and modern smoking methods using coconut shells.

## 2 Method

### 2.1 Materials

The materials used in this study were aluminum foil, ammonium acetate ( $C_2H_3O_2NH_4$ ), acetic acid ( $CH_3COOH$ ) p.a, acetyl acetone ( $CH_3COCH_2COCH_3$ ), hydrochloric acid (HCl) 0.02 N, sulfuric acid ( $H_2SO_4$ ) 1.2 M, liquid smoke grade 2, distilled water, phosphoric acid ( $H_3PO_4$ ) 85%, thread, Coomassie Brilliant Blue (CBB) G-250, ethanol ( $C_2H_5OH$ ) 95%, formaldehyde ( $H_2CO$ ) 37%, dumbo catfish (*Clarius garapianus*), activated carbon, Whatman paper no. 42, universal paper, sodium hydroxide (NaOH) 2 N, sodium chloride (NaCl), n-hexane, coconut shell, and active zeolite.

### 2.2 Conventional Method

Dumbo catfish (*Clarias gariepinus*) are prepared by removing mucus, gills, and entrails, followed by thoroughly cleaning blood and dirt with running water. Next, the fish is soaked in a 25% salt solution for 15 minutes and then drained until the water content decreases.

The smoking process involves smoking the dumbo catfish for 2 hours directly, followed by neutralizing the temperature of the fish at room temperature [3].

### 2.3 Modern Method

The Grade 2 liquid smoke production process begins by cleaning the coconut shells from dirt and coir. Large coconut shells are then cut into small pieces and dried in direct sunlight until fully dry. Weigh 7, 8, and 15 kg of coconut shells and place them into the combustion tube, which has been assembled with the tool components.

The device is then turned on, and the liquid smoke is collected in a container. The liquid is settled for one week before 200 mL is taken and introduced into a distillation device, with the distillate collected. The liquid smoke distillate is then flowed into an active zeolite column (1:10), producing a safe liquid smoke filtrate.

Next, the active zeolite filtrate is passed through a column containing activated carbon (1:0.5), resulting in grade 2 liquid smoke with a mild and painless smoke odor, ready for use.

Modern smoking involves immersing dumbo catfish (*Clarias gariepinus*) into a 50% liquid smoke solution for 30 minutes. The fish is then drained for approximately 5 minutes before analysis [4].

## 2.4 Proximate Analysis

Water content was determined using the method by [5], through drying by vacuum oven until the weight remained constant. Ash content was measured following the procedure of [6], which involved placing the measured sample in a pre-dried and pre-weighed porcelain crucible. The porcelain crucible was then incinerated in an air atmosphere at temperatures exceeding 550 °C. After cooling to room temperature inside a desiccator, the crucible was weighed again.

Fat content was also analyzed using the same method as described by [5], employing Soxhlet extraction. Protein isolation and determination of soluble protein were conducted using the modified methods of [7] and [8]. The method utilized a UV-Vis spectrophotometer at a wavelength of 595 nm. Preparation of the Bradford reagent and the standard solution followed the protocol outlined by [9].

## 2.5 pH

The sample was smoothed and weighed (1 gram) into a glass cup. Then, 10 mL of distilled water was added and stirred thoroughly. The pH of the sample was measured using a pH meter, with the pH value recorded once the digital reading stabilized [10].

## 2.6 Formaldehyde

The formaldehyde test followed the methods of [11] and [12] with modifications. **Standard Dilution:** The formaldehyde standard (37%) was diluted to 0.75, 1.5, 3.0, and 6.25 mg/L. **Preparation of Nash Reagent:** Weigh 150 g of ammonium acetate, pipette 3 mL of acetic acid, and 2 mL of acetylacetone. Dissolve the mixture with distilled water to a final volume of 1 liter. **Sample Treatment:** Place 10 grams of meat into an Erlenmeyer flask, then add 100 mL of distilled water. Homogenize and centrifuge at 3000 rpm for 10 minutes. Separate the supernatant and collect it into a 100 mL volumetric flask, adjusting to the limit mark. Take 2 mL of the sample and transfer it to a test tube, add 2 mL of distilled water and 4 mL of Nash reagent, then mix using a vortex. The mixture was then heated in a water bath at 37 °C for 30 minutes. Absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 415 nm, with distilled water as a blank.

## 3 Result and Discussion

The smoked fish produced from the conventional method has a moderate smoke aroma, with a brown and black surface appearance. The initial stage for the modern method involves the production of liquid smoke from coconut shells through a pyrolysis process. This process breaks down the compounds in the raw material during combustion, which then condenses into a liquid known as liquid smoke. Based on the research conducted, 113 kg of coconut shell yielded 3.67 liters of concentrated brownish-yellow liquid smoke with a pungent smoke odor, categorized as grade 3. This finding aligns

with the study by [13], stating that grade 3 liquid smoke typically presents a concentrated brownish-yellow color with a strong aroma. The liquid smoke is then allowed to settle for one week. The settled liquid smoke can be seen in Figure 1 below.



**Fig. 1.** Grade 3 Liquid Smoke after standing for 1 week

The next stage of purification by distillation, liquid smoke used 200 mL each so that the data obtained in Table 1 below.

**Table 1.** Liquid Smoke Distillation Results

Distillation time (hour)	Temperature (°C)	Distillate (mL)	Residue (%)
2.5	98	188	6
3	94	172	14

The clear yellow-colored distillate is continued for filtration with zeolite and activated carbon (1:10). The resulting filtrate is light yellow in color, and this last stage is called grade 2 liquid smoke can be seen in Figure 2.



**Fig. 2.** Liquid Smoke Grade 2

The grade 2 liquid smoke obtained has a light smoke odor and is not pungent so it is used as a preservative to continue modern smoking. Based on the quality test of smoked fish through proximate analysis, pH and formaldehyde from conventional and modern smoking methods can be seen in Table 2 and Table 3 below.

**Table 2.** Proximate Analysis of Dumbo Catfish (*Clarias gariepinus*) Based on Fumigation Method

No.	Proximate Analysis	Conventional	Modern
1	Water Content	67,92 %	78,01 %
2	Ash Content	3,44 %	3,32 %
3	Fat Content	27,64 %	36,65 %
4	Protein Content	0,001 %	0,003 %

**Table 3.** pH and Formaldehyde Analysis of Dumbo Catfish (*Clarias gariepinus*)

Fumigation Method	Analysis	
	pH	Formaldehyde (ppm)
Conventional	7,17	1,15
Modern	5,07	0,15

## 4 Proximate Analysis

### 4.1 Water Content

The standard moisture content for smoked fish, as defined by the Indonesian National Standard (SNI), is a maximum of 60-65%. However, smoked fish produced using both conventional and modern smoking methods exhibit moisture content exceeding this standard. Elevated moisture content can significantly impact the quality of the final smoked fish product.

As shown in Table 2, the modern smoking method results in higher moisture content compared to the conventional method. This increased moisture level in fish processed with liquid smoke is influenced by the soaking process. The relatively short soaking duration leads to an unstable water evaporation process during drying, which in turn maintains a high moisture content. According to research [14], soaking tuna for three hours reduced its moisture content by 69.32%.

The conventional smoking method, on the other hand, shows a more substantial reduction in moisture content, likely due to the longer smoking duration. Research [15] indicates that extended smoking time results in more complete combustion of coconut shells, further influenced by the surrounding oxygen supply. Increased fuel and prolonged smoking raise the temperature over time, thereby accelerating the evaporation of water from the smoked material.

## 4.2 Ash Content

Ash content is one of the parameters of the nutritional value of food ingredients, representing inorganic substances such as minerals that play a crucial role in building and regulating substances. In this study, the fish meat was pre-dried at a temperature of 80 °C to facilitate water evaporation, accelerating the smoking process and preventing excessive smoke emission from the furnace due to residual moisture.

Based on the results presented in Table 2, the ash content of the two smoking methods does not differ significantly. This similarity is influenced by the salt concentration, which impacts the ash content obtained. According to research [16], the addition of NaCl increases the sodium mineral content in fish meat, thereby raising the ash content. This effect is evident in the ash content test of dried fish with a 30% NaCl preservative-coconut shell liquid smoke, showing an ash content of 24.40%.

## 4.3 Fat Content

The value of fat content using modern smoking methods is higher than with conventional methods, according to [17], due to the presence of phenol, which prevents fat from hydrolyzing. The antioxidant effect of smoke (phenol) on the prevention of fat damage indicates that the longer the soaking process, the higher the concentration of phenol in fish samples, thereby inhibiting fat degradation. Products undergoing hydrolysis tend to become rancid, affecting the quality of smoked fish.

The fat content in food is highly influenced by heating temperature and duration. Heating above 55 °C leads to fat melting, reducing the fat content in the fish. Similarly, prolonged heating causes more fat to evaporate. The fat component can also react with smoke compounds, where the extended smoking process reduces the fat content percentage. Fat is a volatile component, and exposure to hot smoke causes the fat within the fish to melt and coat the surface of the meat.

Therefore, the modern method effectively prevents hydrolysis reactions in fat, as indicated by the higher fat content obtained, while the conventional method promotes hydrolysis reactions, as reflected in the lower fat content measured.

## 4.4 Protein test

Determination of protein content using UV-Vis spectrophotometer with Bradford method, to measure the concentration of soluble protein. The isolate obtained was measured for protein content using the Bradford method, the principle of this method is based on the formation of a complex between Coomassie Brilliant Blue (CBB) and protein solution measured at a wavelength of 595 nm. The formation of the complex is due to the bond between the CBB dye and the protein through ionic interaction between the sulfonic acid group and the positive charge of the protein, namely the amine group. Table 2 shows the soluble protein content of dumbo catfish meat using conventional and modern smoking methods, the soluble protein content of modern smoking is higher at 0.03% while conventional smoking is 0.01%. Proteins that are soluble in salt and dilute acids are thought to be globular proteins that are spherical in shape found in body tissue fluids easily changed under the influence of temperature. Globular proteins include

albumin, globulin, histones and protamine. Globular proteins consist of polypeptides that join each other (tightly folded) to form solid spheres. For example, actin, myosin, tropomyosin, albumin, and myoglobin. These proteins are soluble in salt (myofibrillar proteins) and water (sarcoplasmic proteins). Myofibrillar proteins are slightly soluble in water at neutral pH but soluble in strong salt solutions. Sarcoplasmic proteins have physical and chemical properties, for example, most sarcoplasmic proteins have relatively low molecular weight, high isoelectric pH, and spherical structure. These physical characteristics are responsible for their high solubility in water. The content of NaCl and liquid smoke has a high osmotic pressure so that it can draw water from fish meat and cause denaturation and coagulation of proteins, this results in shrinkage of fish meat and separated proteins. The protein will precipitate and not dissolve easily. The addition of NaCl and liquid smoke results in increased protein levels. So it can be concluded that modern smoking can produce higher soluble protein than conventional smoking.

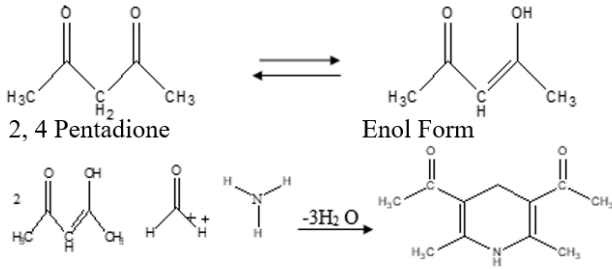
## 5 pH Analysis

Based on the results obtained using a pH meter, the data obtained as in Table 3, the lowest pH value is found in the modern smoking method which shows an increased acid level with a pH that permeates the fish meat around pH 5. This is in accordance with the research [4], that at 50% liquid smoke concentration for soaking tuna steaks has an average pH value of 5.54. The pH value with the modern method is classified as acidic, a low pH value means that the liquid smoke produced is of high quality, especially in terms of its use as a preservative. A low pH value overall affects the durability and shelf life of smoke products or their organoleptic properties. According to [18], the pH value is related to the total phenol content produced, where the higher the total phenol content in liquid smoke, the lower the pH value (the more acidic liquid smoke). According to [18] a good pH for preserved fish is between 2.0 - 5.5 while a pH between 6.0 - 8.0 is a good medium for the growth of microorganisms. Thus, modern smoking produces a good pH and inhibits the growth of microorganisms compared to conventional smoking.

## 6 Formaldehyde Analysis

Determination of formaldehyde content was carried out by visible light spectrophotometric method using Nash reagent containing a mixture of ammonium acetate, glacial acetic acid, and acetyl acetone water. Formaldehyde in the presence of acetyl acetone and ammonium acetate will form a yellow 2,6-dimethyl-3,5-diacetyl-1,4-dihydropyridine compound. Formaldehyde with the addition of Nash reagent accompanied by 30 minutes of heating will produce a steady yellow color so that its absorption can be measured using visible light spectrophotometry at a wavelength of 412-415, following the reaction of formaldehyde with Nash reagent in Figure 3.

According to WHO (World Health Organization), the tolerable daily intake per oral for formaldehyde is 0.15 mg/kgBB. Meanwhile, according to USEPA (United States Environmental Protection Agency) the maximum dose is 0.2 mg/kgBB/day. Canada sets the TDI (Tolerable Daily Intake) value at 0.15 mg/KgBB/day. According to a safe study from the [1] in 2014, smoked fish recommended a formaldehyde limit of 35 mg/Kg. As



**Fig. 3.** Reaction of formaldehyde with Nash reagent

shown in Table 3, the formaldehyde content in the conventional smoking method is higher than the modern smoking method, this is due to the influence of high and uncontrolled temperatures. Formaldehyde is formed from burning coconut shells in the form of smoke with high temperatures, which accelerates the evaporation of formaldehyde and sticks to the surface of the fish and then penetrates into the fish body. While modern smoking methods with controlled temperatures contain low formaldehyde. When referring to WHO, USEPA and Canada, formaldehyde in modern smoking is still within safe limits. However, conventional smoking exceeds the safe limit. Referring to the Directorate of Processed Food Standardization, conventional processed smoked fish is still within safe limits.

## 7 Conclusion

Based on the results of the study, it can be concluded that the smoking process using both conventional and modern methods on dumbo catfish (*Clarias gariepinus*) showed distinct quality differences. In the conventional method, after weeding, cleaning from dirt and blood, and soaking in a 25% salt solution, the fish was smoked directly over the fire source for 2 hours and then neutralized at room temperature. In contrast, the modern smoking method involved soaking the fish in a 50% liquid smoke solution for 30 minutes, followed by draining. The quality assessment of smoked dumbo catfish through proximate analysis, pH measurement, and formaldehyde testing indicated that the modern smoking method produced higher quality smoked fish compared to the conventional method.

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