The effect of different variety of fire-woods on smoking of *selais* catfish (*Cryptopterus bicirchis*)

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Abstract. Problems encountered in traditional fish smoking was the inconsistency in the quality of the smoked fish produced, and so making the product provided less quality assurance to consumers. The type of fire-wood used as smoke fuel was also uncertain because it depended on the availability of the wood surrounding the smoking activity area. The aim of the research was to describe the method of traditional fish smoking and to determine the best typical wood used to produce smoked fish in the Province of Riau, Indonesia. The experimental method was used to examine the use of different kinds of fire-wood as the smoke source for *selais* catfish (*Cryptopterus bicirchis*) smoking. Several fire-woods used were kandis (*Garcinia xanthochymus*), laban (*Vitex pinnata*), ubar (*Eugenia* sp.) and timah-timah (*Elaeocarpaecae* sp.). The result showed that the *catfish smoking in the province was applying direct hot smoking method. Smoked catfish produced was showing somewhat blackish brown, shiny, dry and clay textured, and weight reduction up to 25% from initial weight. The best wood used as smoke source was ubar wood, but not significantly different to laban wood. The best smoked fish produced was containing moisture, total phenolic and acid compound at 11.26%, 0.745%, and 0.92%, respectively.

1. Introduction
The main purpose of curing the fish is to extend the shelf life of the product and also to obtain a certain appearance and flavor of smoke[1]. While Sikorski [2] and Visciano et al. [3] stated that smoking in various food products is a preservation method that not only increases the shelf life, but it also provides a typical flavor and color of the smoked product. Varlet, et al. [4] explained that the European smoked fish consumers used liquid smoke referring to get the smoke flavor and aroma of the fish rather than its shelf life.

The production and the use of liquid smoke for food products were developed rapidly. It was shown by the amount of researches on the production of liquid smoke from varied raw material as sources of smoke, such as: the use of various types of wood and coconut shell [5], *Vitis veninera* [6], some agricultural wastes [7], *Fagus sylvatica* [6], *Salvia lavandulifolia* [8], solid wastes of spices and rubber wood [9], cassava wood [10], oak *Quercus* sp. [8], and lamtoro wood and corncobs [11].

There are several factors that affect to the characteristics of the produced smoke during combustion process of the wood. Guillen and Ibargoitia [6] noted several affecting factors, such as types of wood or fuel material ([12] and [13]), the temperature during the smoking process [13], the air volume during smoking process and the size of the wood pieces and moisture content of the wood [13].

Problems encountered in traditional fish smoking was the inconsistency in the quality of the smoked fish produced. The type
of wood used as smoke fuel was also uncertain because it was depending on the availability of the wood surrounding the smoking activity area. Thus, the best wood used in this province still had not been determined as the typical raw material of smoke fuel for selais catfish (Cryptopterus bicirchis) smoking in Riau Province Indonesia. The fish smoking process was conducted traditionally based on the skills passed from generation to generation. The process of the fish smoking was still carrying minimal touch of technology and low development of better methods of smoking. Another problem in traditionally fish smoking was the content of carcinogenic compounds in smoked fish processed by applying direct hot smoking. Traditional smoking method was produced relatively higher content of the unhealthy compound rather than it processed by applying the liquid smoking method, which could be more controlled. Based on these conditions, it is necessary to investigate and determine the best type of wood and to use it as a typical fire-wood to produce the smoked selais catfish mostly preferred by consumers.

2. Methodology

2.1. Sample preparation
Fresh samples of selais catfish (Cryptopterus bicirchis) were purchased from the fishermen at the regency of Rokan Hilir Province of Riau, Indonesia. Each sample weight was about 20-25 grams and the total fish purchased was 50 kgs.

2.2. Smoke source
Four types of wood used for fish smoking: kandis wood (Garcinia xanthochymus), laban wood (Vitex pinnata), ubar wood (Eugenia sp.), and timah wood (Elaeocarpaceae sp) which were collected around the processing area. The diameter of woods was 8-12 cm. They had been sun-dried for several days before used.

2.3. Methods
The research used the methods of survey and experiment on traditionally fish smoking, to determine the effect of different types of wood used for selais catfish smoking. The smoking process was conducted in Regency of Rokan Hilir in Riau Province where found many business units of selais catfish smoking. Some types of wood were tried to be used to smoke the fish traditionally by applying direct hot smoking. The survey was conducted by collecting the traditional smoked fish from the processing area followed by analyzing them in the laboratory to evaluate their smoked fish profile produced. The smoked catfish produced by using of each type of wood was analyzed and evaluated for their sensory characteristics and their consumer acceptance. The consumer preference to smoked fish was evaluated by 25 semi-trained panelists by using a score sheet. The scoring method for the hedonic test was used to assess the value of appearance, odor, taste, and texture of the smoke fish. The hedonic score was ranging between 1 and 9, based on the standardized quality of smoked fish according to SNI 01-2725.1-2009 [14]. Score 1 was the lowest score (extremely disliked), 5 (fair) and 9 was the highest score (extremely like). Moreover, it also conducted chemical analyses to determine the water content, aw, pH, total acid content [15], and total phenols [16] on the smoked fish. Each type of wood smoke material was also analyzed for their chemical composition, namely the content of lignin, cellulose and hemicellulose.

3. Results and discussion

3.1. Profile of smoked fish
There were found many catfish smoking business units in the Regency of Rokan Hilir the Province of Riau, Indonesia. Traditional fish smoking process and the smoked *selais* catfish produced can be seen at Figure 1.

![Image](image_url)

(a)

(b)

Figure 1. The process of fish smoking (a) and smoked *selais* catfish produced (b)

The construction of smoke house used for fish smoking in the Regency of Rokan Hilir was very simple (as seen on Figure 1). It was equipped with some bamboo trays where the fish was lied on. There were some material woods burned below the bamboo trays to produce heat and smoke during the process of fish smoking.

The trays were inserted into the shelves in the smoking chamber, while the firewood was burned in the burning chamber below. The smoking process conducted earlier with the initial temperature of 80-90°C for two hours, and then the temperature was lowered to 60°C for one hour and was lowered again to 50°C for 1-3 hour. The smoking process was finished when the smoked catfish is blackish brown, shiny, dry and clay textured, and the weight was reduced to 25% of initial weight.

Smoked catfish with traditional smoking in Riau Province could be stored for more than a month at room temperature (28-31°C). Beside of its dry texture, the smoked fish also contains some preservative compound derived from smoke, namely phenolic and acid compounds. The smoking can extend the shelf life of fish products by inhibiting the activity of enzyme [17] and suppress the growth of microbes [18]. Preservatife effect is caused by the presence of some antimicrobial and antioxidant compounds in the smoke. These compounds also give a distinctive color and flavor of meat or smoked fish [19], [20], and [21].
3.2. Consumer preference

The consumer preference of smoked catfish was evaluated by their sensory analysis. The sensory analysis of smoked catfish using different variety of woods could be seen in Table 1.

Table 1. Sensory characteristics for smoked *selais* catfish (*Cryptopterus bicirchis*) by using different variety of wood

| Type of wood     | Appearance | Aroma    | Flavour   | Texture   |
|------------------|------------|----------|-----------|-----------|
| *Kandis* (G. xanthochymus) | 7.15±0.11  | 6.97±0.18 | 6.55±0.38 | 7.16±0.03 |
| *Laban* (Vitex pinnata)        | 7.14±0.06  | 7.20±0.14 | 7.00±0.10 | 7.37±0.12 |
| *Ubar* (Eugenia sp.)          | 7.33±0.18  | 7.34±0.11 | 7.15±0.12 | 7.46±0.11 |
| *Timah* (Elaeocarpaceae sp.)  | 6.95±0.07  | 7.02±0.10 | 7.06±0.16 | 7.29±0.02 |

Note: The score of hedonic is ranging between 1 and 9. Score 1 is the lowest score (extremely disliked), 5 (fire), and 9 is the highest score (extremely like). Hedonic score is shown as a mean and a deviation standard (p=25, r=3). Different superscript letters within the same column indicate significant difference (P<0.05)

Consumer preference on smoked catfish produced by using different types of firewood was analyzed for its hedonic score, includes the attributes of appearance, taste, odor, and texture. The smoked catfish with *ubar* wood as smoke source gave the highest score for all attributes. However, the score has no significant difference with *laban* wood (p<0.05). *Laban* wood produced better sensory quality of smoked fish. Some panelists preferred to *laban* wood because of its bright color and appearance. The appearance is brownish but shinier than the others. The consumer preference of smoked fish was primarily based on the color of the smoked fish. The best appearance of smoked fish is characterized by its surface color, which is golden brown. Girard [1] explained that carbonyl compounds have a major influence on the color. Smoked product color due to the interaction between the carbonyl amino group through the Maillard reaction.

The texture of the smoked catfish produced by using *laban* wood was not significantly different to *ubar* wood (P>0.05). It was also correlated to its lowest water content and the content of moisture was not significantly different each other. The results indicate that the different type of firewood affects the flavor of produced smoked fish. *Laban* wood is the best type of firewood used for smoke fuel rather than the other woods. The taste is better and the flavor is smokier which give a distinct characteristic of a smoked fish. It may be caused by the higher of total phenol contained in the smoked fish produced. Girard [1] stated that the content of chemical components in the smoke is influenced by different types of wood materials used, especially the content of phenolic compound. Chemical components in the smoke can be used for determining the quality of the smoked products. Woody, et al. [22] explained that the effect of different types of firewood to the flavor of smoked product was caused by the formation of the basic patterns of smoke over wood decomposition by heat. Hardwood produces good color and taste of smoked product, but the smoking process will take longer time than softwood.

Smoke generated from the burning of hardwood will vary with the composition of smoke produced from burning of softwood. The different types of materials of wood’s smoke produces different complex chemical composition, which is a mixture of structural volatile and non-volatile compounds with different sensory characteristics, such as phenol, guaiacol and syringol and their derivatives [23].
The difference in value in such a fish slice smoked allegedly due to the reaction of components of smoke carbonyls with a protein contained in fish meat slice that will affect the value of such a fish slice smoked become yellowish brown it in accordance with the opinion of Ruiter [24], carbonyl has the greatest effect on the formation brown in smoked fish products. Carbonyl component types that were most responsible are glyoxal aldehydes and glyoxal metals while formaldehyde and hydroxacetol provide role lace. Phenols also contribute to the formation of brown color on the product being smoked although the intensity is not as big as carbonyl.

The highest value of aroma is resulted by the use of ubar wood, but not significantly different to laban wood. Girard [1] states that the smell of smoke formed largely influenced by the presence of phenols and carbonyl compounds, and a fraction is also influenced by the acid. The phenolic compounds that play a role in the formation of the aroma of the smoke is syringol.

### 3.3. Physico-chemical characteristic

Table 2 is showing the physico-chemical characteristics of smoked selais catfish (Cryptopterus bicirchis) with different variety of woods.

Table 2. Physico-chemical characteristics of smoked selais catfish (Cryptopterus bicirchis) with different variety of woods.

| Type of wood      | Phenols (%) | Organic Acids (%) | pH       | Ash (%) | Moisture (%) |
|-------------------|------------|------------------|----------|---------|--------------|
| Kandis (G. xanthochymus) | 0.742±0.001<sup>a</sup> | 0.74±0.20<sup>a</sup> | 6.52±0.19<sup>a</sup> | 1.88±0.02<sup>a</sup> | 10.77±0.09<sup>a</sup> |
| Laban (Vitex pinnata) | 0.745±0.002<sup>a</sup> | 0.92±0.35<sup>a</sup> | 6.51±0.10<sup>a</sup> | 1.90±0.03<sup>a</sup> | 11.26±0.08<sup>a</sup> |
| Ubar (Eugenia sp.) | 0.758±0.001<sup>a</sup> | 1.00±0.33<sup>a</sup> | 6.49±0.16<sup>a</sup> | 1.89±0.02<sup>a</sup> | 11.24±0.01<sup>a</sup> |
| Timah (Eugenia sp.) | 0.741±0.002<sup>a</sup> | 1.13±0.20<sup>a</sup> | 6.51±0.09<sup>a</sup> | 1.77±0.02<sup>a</sup> | 11.26±0.04<sup>a</sup> |

Note: Different superscript letters within the same column indicate significant difference (P<0.05)

Phenol is a smoke chemical compound used to determine the quality of the smoke. Identification of phenol to the quality of the resulting smoke is expected to represent the criteria of the quality of the smoke, so its use is more appropriate target. Analysis indicated phenol content to determine the level of uptake of phenol by the fish meat. Differences in the levels of phenol allegedly by differences in the type of wood used as a source of the smoke. The difference in the use of smoking affects the levels of phenols in the smoke produced. Differences in levels of phenol in smoke component caused by differences in lignin contained in smoke source materials. The typical flavor and aroma of smoked fish is mostly influenced by the phenol contained in wood smoke. The higher the phenol content in the smoke, the stronger aroma and taste of the smoked fish produced.

The differences of total acids content in each treatment allegedly because of differences in the content of hemicellulose and cellulose on the type of wood used as a source of the smoke. The difference in acid levels due to differences in the content of hemicellulose and cellulose on smoke material which decomposes during the pyrolysis process at a temperature of 300 °C combustion. The content of total acid is one of the chemical properties which determine the quality of the resulting smoke. Organic acids that have a high role in the utilization of the smoke is acetic acid, acetic acid is formed in part from the lignin and part of the carbohydrate component of cellulose. The components in the timber include acid which can affect the taste of the product, pH and carbonyl reacts with proteins to form brown dye and phenol which is the main form of scent and showed antioxidant activity.
The pH value indicates the level of the wood components decomposition process that occurs to produce organic acids in the smoke. When the smoke has a low pH value, then the resulting smoke product quality will be higher, because the overall effect on the durability and organoleptic value.

3.4. Chemical composition of smoke wood

Evaluation of the chemical composition of the wood was included the content of water, hemicellulose, cellulose and lignin. The data of chemical composition of smoke wood can be seen in Table 3.

Table 3. The chemical composition of the smoke wood

| Type of wood       | Chemical Composition (%) |     |
|-------------------|--------------------------|-----|
|                   |                          | Moisture | Cellulose | Lignin | Hemicellulose |
| Kandis (G. xanthochymus) |                          | 9.89 | 48.43 | 26.90 | 12.73 |
| Laban (Vitex pinnata)     |                          | 10.11| 48.18 | 26.42 | 11.47 |
| Ubar (Eugenia sp.)        |                          | 10.26| 49.73 | 29.27 | 7.95  |
| Timah (Eugenia sp.)       |                          | 9.55 | 48.81| 26.65 | 11.47 |

The temperature of woods pyrolysis in this research was conducted at 350 °C for about an hour. The temperature determined was referring to Girard [1] stated that the components of wood, such as cellulose, will decomposed to produce organic acids and lignin will produce phenol and guaiacol. If the temperature exceeds or above the temperature used, the wood pyrolysis will produce very high amount of tar charcoal. Producing liquid smoke from agricultural waste at a temperature of 400 °C will take time for approximately an hour [7].

The highest yield of liquid smoke produced from the results of this study is liquid smoke from wood laban. It proves that the component content of lignin and cellulose in the wood is quite high and not different to the type of wood kandis, wood ubar, and wood timah. In addition, the density of the wood species also affects the condensate liquid smoke.

In the production of liquid smoke there is also a weight loss. Weight is lost in the form of gas which is not condensed and evaporated passes through the condenser and the crust left on the lid of the tube, pipe and condensate pyrolysis. The missing component in the form of carbon dioxide, carbon monoxide, H₂, CH₄ and some hydrocarbons. Gases which cannot be condensed formed in pyrolysis hardwood, contain carbon dioxide, carbon monoxide, hydrogen, methane and other hydrocarbons the main constituent. The process of refining the liquid smoke made by distillation, a process which separates tar and compounds that are harmful such as polycyclic aromatic hydrocarbons (PAH) and the active substances contained in the liquid smoke of phenols, acid, carbonyl properties lasting power is high and giving color as well as taste. In the distillation process must not be separated from the temperature used, i.e between 100° - 150° C. At these temperatures occur evaporation process that separates compounds of organic acids and phenolic compounds in the liquid smoke [9].

4. Conclusions

The smoking of catfish selais (Cryptopterus bicirchis) in Riau Province Indonesia was conducted traditionally by applying direct hot smoking methods. The smoked catfish is showing blackish brown, shiny, dry and clay textured, and the weight was reduced to 25 % of initial weight. The best wood as fuel wood for catfish selais smoking was wood laban (Vitex pubescens), as a typical regional firewood from Riau.
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