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Profile of traditional smoking striped catfish (*Pangasius hypophthalmus* Sauvage 1878) and firewood used in province of riau, Indonesia

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Key words: hardwood, hot smoking, *Vitex pubescens*, phenolic compound, smoke flavor.

Abstract

This study was aimed to describe the profile of traditional striped catfish (*Pangasius hypophthalmus* Sauvage) smoking in Province of Riau, Indonesia. The study was collected data about the method of traditional smoking by survey. The survey was followed by the sampling and the laboratory analysis on the profile of produced smoked catfish and the best type of firewood used for fuel and smoke source. The laboratory analysis includes physico-chemical characteristics and sensory analyses. Results showed that fish smoking in Riau is applying direct hot smoking method. The smoking process is conducted in two stages. The first stage is roasting at the smoking temperature of 60-90°C for four hours, continued with drying stage at the smoking temperature of 40° C for about five hours. The product of smoked catfish was blackish brown, shiny, dry and clay textured, and the weight reduced to 31% from initial weight. The best type of firewood was *Laban* (*Vitex pubescens* Vahl). The smoked catfish using *Laban* firewood as smoke source showed the highest content of total phenols 0.060 ± 0.003%, with the value of a_w 0.680 ± 0.05, and pH 6.65 ± 0.12. The smoked catfish produced was the most preferred by panelists, especially its appearance and odor, with the average of sensory value 7.4. This sensory value is above the minimum standard value 7.0 determined by the Agency of National Standard in Indonesia for smoked fish.

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Introduction

Fish smoking conducted in Province of Riau Indonesia was aimed to provide smoke flavor to the fish and simultaneously to extend the shelf life of the smoked fish. Several studies conducted by Girard (1992), Sikorski (2005) and Visciano *et al.* (2008) showed that smoking on various food products is a preservation method that not only increases the shelf life, but also gives the distinctive flavor and color of the product. Pszczola (1995) emphasized that the main purpose of smoking is to provide the desired flavor and color of the product due to the presence of phenol and carbonyl compounds in smoke. Another purpose is to preserve the smoked product, because the content of acids and phenolic compounds act as antibacterial and antioxidant. However, recent development reported by Varlet *et al.* (2007) was that the preference of consumers in Europe to smoked fish preferred more due to the smoke flavor and aroma on the fish rather than its shelf life.

There are several factors that affect to the characteristics of the produced smoke during combustion process of the wood. Guillen and Ibargoitia (1999) noted several affecting factors, such as types of wood or fuel material (Baltes *et al.,* 1981; Maga and Chen, 1985), the temperature during the smoking process (Hamm and Potthast, 1976; Toth, 1980; Maga and Chen, 1985), the air volume during smoking process (Daun, 1972), and the size of the wood pieces and moisture content of the wood (Maga and Chen, 1985).

The different materials of firewood produce the different complex chemical composition. The chemical composition of the wood is a mixture of structural volatile and non-volatile compounds with the different sensory characteristics, such as phenol, guaiacol and syringol and their respective derivatives (Kostyra and Baryłko-Pikielna, 2006). Phenol is a major contributor to the wood smoke flavor, but other compound groups are also important. Some phenolic compounds, namely guaiacol, 4-methylphenol and 2,6-dimethoxyphenol, have been described as having a smoky odor (Maga, 1988). Fine types of firewood for smoking fuel are the types of hardwood. Smoke generated from the burning of hardwood will have different composition to the smoke generated from softwood. In general, hardwood will produce superior flavor, higher content of aromatic and acidic compounds more than those produced by softwood (Girard, 1992). Murniyati and Sunarman (2000) also informed that wood resin-containing is not good for smoking fish for causing unpleasant odor and taste.

The process of smoked fish in Riau generally uses any type of firewood as smoke fuel, depending on the availability of the wood surrounding the smoking place (Leksono *et al.*, 2009). Some types of firewood used as smoke fuel were *Laban* wood (*Vitex pubescens* Vahl), *Medang* wood (*Litsea firma* (Blume) Hook. f.), and *Rambutan* wood (*Nephelium lappaceum* L.). The use of these three types of firewood could produce bright and shiny smoked fish, with the aroma and flavor that were highly preferred by consumers. The results of this study provide information about striped catfish (*Pangasius hypophthalmus*) smoking in Province of Riau Indonesia, includes the methods and the process of traditional catfish smoking and a type of firewood which produce the best flavor of smoked catfish.

Materials and methods

Sampling

The sample used in the research was striped catfish (*Pangasius hypophthalmus*), a species of freshwater catfish usually processed as smoked fish in Province of Riau, Indonesia. The fish was cultured in pond and their condition was fresh for smoking, because it was alive when handled. The weight of catfish samples were 225-275 g each.

Three types of firewood used as smoking fuel were the types of hard wood. They were *Laban* (*Vitex pubescens*), *Medang* (*Litsea firma*), and *Rambutan* (*Nephelium lappaceum*). The diameter of woods was 8-12 cm. They were sun-dried for several days before used.

Survey Method

The first step of the study was conducting surveys on the traditional smoked fish in Province of Riau, Indonesia. The survey was conducted by using a purposive sampling method (Tongco, 2007), based on the regional development center of the farming and processing of catfish in the province. We observe the profile of traditional smoking of catfish, including the smoking method and process, the smoking time and temperature, and the types of firewood used as fuel and smoke source.

Data Analysis

The survey was followed by laboratory analysis on the profile and type of wood used for smoke fuel. The sample of smoked fish were identified and compared based on the difference of the used firewood types as fuel for catfish smoking. Each sample was collected from three different fish smoking units and analyzed for their physico-chemical characteristic, consumer preference, and identification of its volatile compound.

The physico-chemical characteristics were evaluated to determine the proximate composition, includes the content of moisture, protein, fat, carbohydrate, and ash (AOAC, 2000) and the value of pH (Apriyantono *et al.*, 1989), a_w (Fuentes *et al.*, 2010), the content of total acid (AOAC, 1995) and total phenol (Senter *et al.*, 1989). The consumer preference to smoked fish was evaluated by hedonic test. The scoring method was used to assess the score of appearance, aroma, flavor, and texture of the smoke fish. The hedonic score was ranging between 1 and 9, based on the provision of value in standardizing the quality of smoked fish according to SNI 01-2725.1-2009 (BSN, 2009). Score 1 is the lowest score (extremely disliked), 5 (fair) and 9 is the highest score (extremely like). Analysis of volatile compounds in smoked fish is conducted by chromatography method using GC/MS according to Kostyra and Baryłko-Pikielna (2006).

All analyzes for characteristic of physico-chemical and consumer preferences were done in triplicates and the data were subjected to statistical evaluation using Genstat 15. Advanced test of Least Significant Difference (LSD) with $P<0.05$.

Results and discussions

Method and Process of Traditional Fish Smoking

Fish smoking in Riau was conducted traditionally by applying the method of direct hot smoking. The fresh striped catfish was cleaved from the back and cut open, gutted and cleaned, and then placed on the trays with an open upward position. Traditional smoking house used to smoke the fish. The fish was inserted to the rack in the smoking chamber (Fig. 1).

Fig. 1. Traditional smoking house in Riau.

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 with the initial temperature of 80-90°C for two hours, and then the temperature was lowered to 70°C for one hour. Then, the temperature was lowered again to 60°C for one hour until the catfish meat was cooked and most of the fat was melted, and so this process called as the stage of roasting. The next stage after

roasting was drying. The drying stage was conducted by reducing the flame of firewood burning and turned to temperature of 40°C for five hours. The smoking process was finished when the smoked catfish is blackish brown, shiny, dry and clay textured, and the weight was reduced to 31% of initial weight.

Smoking the fish at high temperature cooked the smoked striped catfish. The cooked fish can be achieved when the moisture content in the air increased and raised the temperature of the fish's flesh (Afrianto and Liviawaty, 2005). Ghozali *et al.* (2004) also proved that smoking the fish at temperature of 50°C or more was causing the smoked fish cooked. Swastawati *et al.* (2012) stated that the high temperature during fish processing was causing to denaturation of fish protein.

Catfish was dehydrated and its moisture reduced due to the heating of smoking chamber by the flame of firewood during the smoking process. The heating of air in the smoking chamber caused the hot air flew out of the chamber, thus lowered the humidity in the smoking chamber. The low humidity of the air in the smoking chamber will draw water from the fish flesh, until the equilibrium of water vapor pressure in the flesh and in the air around the fish's surface. This condition is shown by the low value of a_w in smoked fish. Storey (1982) stated that the velocity of air flow and humidity will determine how quick the fish to dry.

Smoked catfish with traditional smoking in Riau can 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 (Lakshmanan *et al.*, 2003) and suppress the growth of microbes (Truelstrup *et al.*, 1996; Bugueno *et al.*, 2003). Preservative 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 (Hattula *et al.*, 2001; Martinez *et al.*, 2007; Muratore *et al.*, 2007).

Physico-chemical Characteristic

The proximate composition of smoked striped catfish was produced by using different types of firewood. It is including the percentage of moisture, protein, fat, carbohydrate, and ash (Table 1). The traditional smoked catfish moisture ranged 17.06 - 17.96%. It means that the smoked catfish is a dry food product, which allows to be stored in a relatively long period (more than a month) at room temperature (28-30°C). Fat content of traditional smoked catfish ranged 10.98 - 11.77%. It means that content of fat in the catfish is very high and allows the smoked catfish susceptible to oxidative rancidity and hydrolysis by fungi. Meanwhile, the protein content of smoked catfish is quite high, 61.46 - 62.16 %. It shows that the smoked catfish has a high nutrient value. The content of carbohydrate and ash of the smoked catfish ranged from 3.38 to 3.47% and from 5.72 to 5.77%, respectively. The fairly high ash content sourced from the mineral content of catfish and smoke particles attached to the surface of the smoked catfish. All of proximate composition values are not significant different (P>0.05) among smoked catfish produced by using different types of firewood. It means that the difference of type of firewood is not affecting to the proximate composition values of smoked fish produced.

Tabel 1. Proximate composition of smoked catfish on different types of firewood.

Type of firewood	Proximate composition				
	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Ash (%)
Laban	17.06 ± 0.49 [a]	62.16 ± 0.39 [a]	10.98 ± 0.42 [a]	3.58 ± 0.15 [a]	5.72 ± 0.16 [a]
Medang	17.96 ± 0.87 [a]	61.46 ± 0.88 [a]	11.15 ± 0.39 [a]	3.51 ± 0.14 [a]	5.77 ± 0.12 [a]
Rambutan	17.12 ± 0.13 [a]	61.79 ± 0.28 [a]	11.77 ± 0.19 [a]	3.57 ± 0.17 [a]	5.74 ± 0.14 [a]

Note: The value is shown as a mean and a deviation standard (r=3). The same superscript letters within the same column indicate no significant difference (P>0.05)

The physico-chemical characteristic of smoked striped catfish produced by using of different types of firewood was including the value of a_w, pH, total acid, and total phenol (Table 2). The content of total phenol in the smoked catfish produced by using *Laban* wood as a fuel and source of smoke indicates the highest value (0.060 ± 0.003%), significantly different to *Medang* wood (P<0.05). However, it is not significantly different to *Rambutan* wood (P>0.05). The higher content of total phenol may cause to the higher value of hedonic, especially for the value of odor and flavor. Thus, the panelists were preferred more to the smoked fish using *Laban* wood.

The phenolic compounds which responsible for flavor formation in smoked food products and also have antioxidant activity which affects their shelf life (Girard, 1992). Components of phenolic compounds that have a role in the formation of flavor are guaiacol, 4-metilguaiakol and 2,6-dimetoksifenol. Guaiacol haves a role in smoky taste, while syringol haves a role in smoky aroma (Daun, 1979). Phenol threshold value of the smoke condensate was 0.147 ppm for taste stimuli and 0.023 ppm for odor stimuli (Ruiter, 1979).

Tabel 2. Physico-chemical value of smoked catfish on different types of firewood.

Type of Firewood	Physico-chemical value			
	a_w	pH	Total Acid (%)	Total Phenol (%)
Laban	0.680 ± 0.003 [a]	6.55 ± 0.12 [a]	0.250 ± 0.023 [a]	0.060 ± 0.003 [a]
Medang	0.689 ± 0.004 [a]	6.62 ± 0.18 [a]	0.262 ± 0.022 [a]	0.048 ± 0.002 [b]
Rambutan	0.682 ± 0.006 [a]	6.56 ± 0.16 [a]	0.259 ± 0.035 [a]	0.058 ± 0.003 [a]

Note: The value is shown as a mean and a deviation standard (r=3). Different superscript letters within the same column indicate significant difference (P<0.05)

The pH value of traditional smoked catfish is approaching neutral pH ranged between 6.62 - 6.66, correlated to the content of total acid from 0.25 to 0.26%. In general, fresh fish has a pH of ± 7, but after being smoked, pH value of smoked fish decreased. The decrease in the pH value in the smoked fish has also been reported by Turan *et al.* (2008). The decrease in the pH value is caused by the increased acidity due to the existence of carboxylic acids, acetic acid and other acids product formed from the burning of wood. The high content of total acids and total phenols generate the smoky flavor and preserve the smoked fish.

Chemical components contained in the smoke attach on the fish surface and penetrate into the fish meat during the smoking process. The amount of smoke absorption depends on the type of wood and the operating method of smoke house. The selection of proper smoking conditions minimize the presence of undesirable compounds (Belitz and Grosch, 1987). Guaiacol contributes to smoke flavor, whereas syringol does not (Daun, 1979). Phenol is also contributing to the coloring of smoked product (Ruiter, 1979), which according to Winarno (1993), one of the effects obtained from the smoking is the change of color to brown. The color change occurs due to the ongoing Maillard reaction between the amino group with the sugar in the flesh of fish caused by heating during the smoking process (Girard, 1992). The brown color change is also caused by the reaction between phenol components in the smoke with fat, protein and carbohydrate components in fish's flesh (Cardinal *et al.* 2006; Swastawati *et al.* 2008).

Consumer Preference

Consumer preference on smoked striped catfish produced by using different types of firewood was analyzed for its hedonic score, includes the attributes of appearance, taste, odor, and texture (Table 3). The smoked catfish produced by using *Laban* wood as a fuel and source of smoke indicates the highest hedonic score but not significantly different to *Rambutan* wood (P<0.05). *Laban* wood produced better sensory quality of smoked fish. 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 colour, which is golden brown (Obodai *et al.*, 2009). Girard (1992) 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.

Table 3. Hedonic score of smoked catfish produced by using of different types of firewood.

Type of Firewood	Appearance	Taste	Odor	Texture
Laban	7.5 ± 0.1 ^{b}	7.3 ± 0.2 ^{b}	7.5 ± 0.3 ^{b}	7.2 ± 0.3 ^{a}
Medang	7.1 ± 0.3 ^{a}	6.8 ± 0.2 ^{a}	7.1 ± 0.1 ^{a}	7.1 ± 0.2 ^{a}
Rambutan	7.3 ± 0.2 ^{ab}	7.2 ± 0.1 ^{b}	7.3 ± 0.1 ^{ab}	7.2 ± 0.1 ^{a}

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)

The texture of the smoked catfish produced by using *Laban* wood was not significantly different neither *Rambutan* wood nor *Medang* wood (P>0.05). It was also correlated to its lowest water content and the value of a_w that was not significantly different each others.

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 *Medang* wood or *Rambutan* wood. The taste was tastier and the odor is smokier, characteristically of smoked fish. It may be caused by the higher of total phenol contained in the smoked fish produced. Girard (1992) 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.* (2000) 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 volatil and non-volatile compounds with different sensory characteristics, such as phenol, guaiacol and syringol and their derivatives (Kostyra and Pikielna, 2006).

Volatile compound in smoked fish

The volatile compounds in smoked striped catfish produced by using three types of firewood analyzed by using GC/MS were shown as the chromatogram in Fig. 2. Based on the chromatogram, the volatile compounds in traditional smoked catfish are categorized into several compound groups, as listed in Table 4.

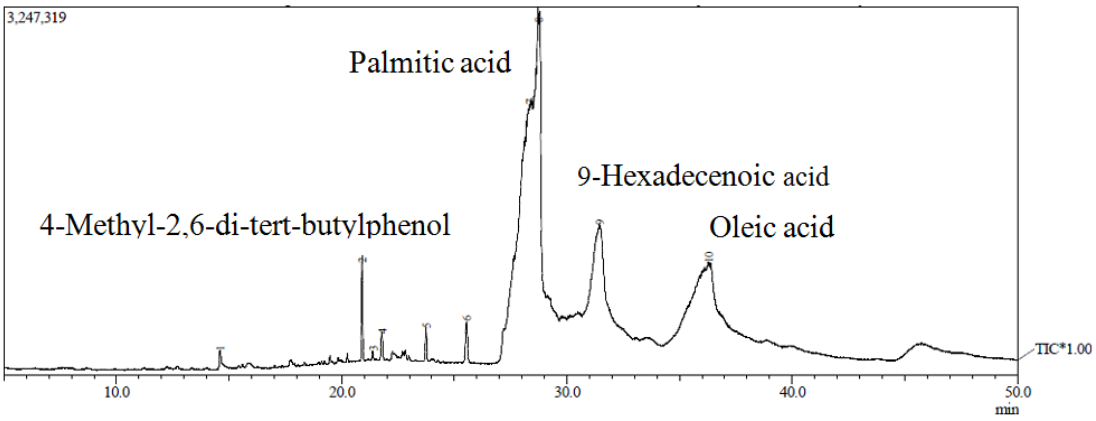
Table 4. The list of volatile compounds contained in traditional smoked striped catfish.

Group of Compound	Smoked by using *Laban* firewood		Smoked by using *Medang* firewood		Smoked by using *Rambutan* firewood	
	Compound name	RA	Compound name	RA	Compound name	RA
Organic Acids	Acetic acid, Hexadecanoic acid, and Palmitinic acid	63.9	Acetic acid, myristic acid, benzoic acid, Metholene, Methyl ester oleic acid, and 2,4-Hexadienedioic acid.	23.0	Acetic acid, Propionic acid, Butanoic acid, Isopentanoic acid , Dodecanoic acid, Palmitinic acid, and Myristic acid.	56.0
Phenolic	9-Octadecenoic acid, Emersol, BHT, Creosol, Phenol, and Syringol	35.5	2-Ethylhexanol , Furfuryl alcohol, 1,3,5-tri-o-methyl-triacetate galactitol, Cyclododecanol, 2-methoxy phenol, BHT, Creosol, Phenol, 4-ethyl-2-methoxy-phenol, 4-methyl-2-phenyl-1,4-pentanediol, 2,3-dimethyl- phenol, 2-methyl-phenol, Dihydroeugenol, Isoeugenol, 2,4-dimethyl-phenol, Syringol, Methylsyringol, and Methoxyeugenol	49.8	2-ethyl-1-Hexanol, 2-methoxy phenol, BHT, Creosol, Homoguaiacol, Phenol, 4-ethyl-2-methoxy-phenol, Creosol, 2,5-dimethyl-phenol, Syringol, and 4-Methoxy-3-phenol	30.3
Other	Myristal-dehyde	0.6	Limonene, 1,2-Dichlorobenzene, Heptadecane, Cyclododecane, Pentadecane, Hexadecane, 1-methyl-2-Pyrrolidinone, Cyclododecane, Farnesene, Naphthalene, Tetratriacontane, 2,5-Dibutylfuran, and 1-methyl- 2,4-Imidazolidinedione	26.8	1-hydroxy- 2-Propanone, Pentadecane, Cyclotene, 3,4-dimethyl cyclopentenolone, 5-Isopropenyl-3-isopropyl-2,2-dimethyl-2,5-dihydrofuran, 3,4,5-Trimethoxytoluene, Acetoguaiacon, and guaiacylacetone	13.8

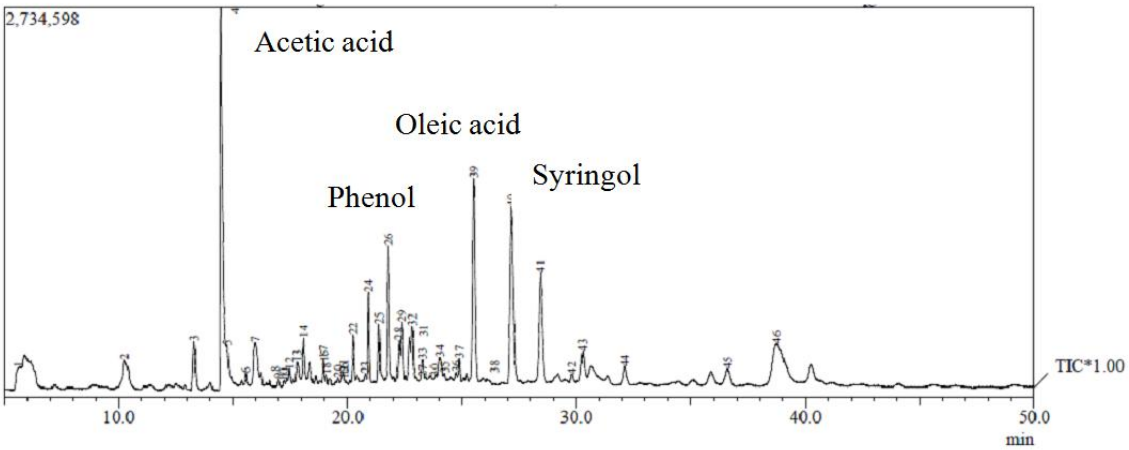
Note: RA means relative percentage of area width (%).

Table 4 indicates that the volatile compounds in smoked catfish produced by using *Laban* firewood were dominated by organic acid. It showed by relative percentage of area width (RA) 63.9%, followed by *Rambutan* firewood and *Medang* firewood with the RA of 56.0% and 23.0%, respectively. Phenolic compounds was dominated in striped catfish smoked using *Medang* firewood, followed by *Laban* firewood and *Rambutan* firewood with the RA of firewood with the RA of 49.8%, 35.5% and 30.3%, respectively.

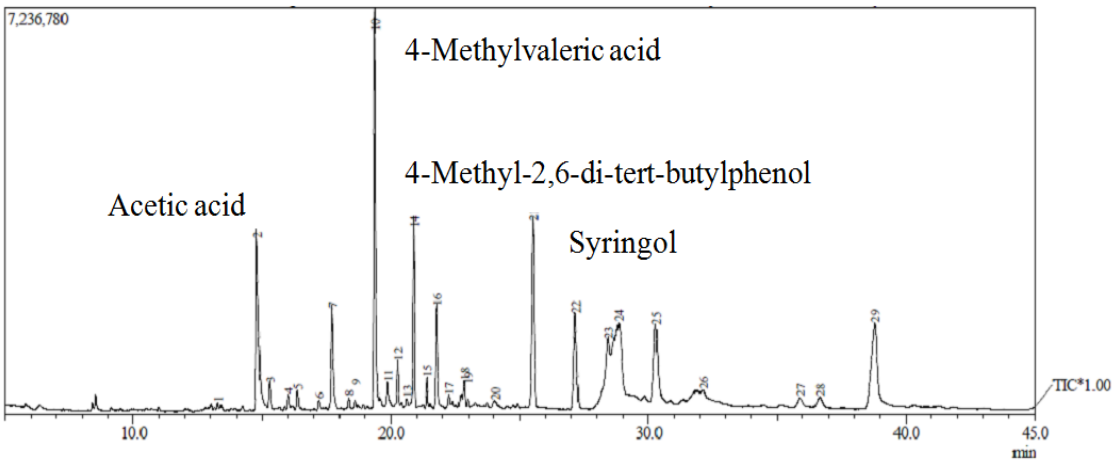
The striped catfish (*Pangasius hypopthalmus*) smoking in Riau Province Indonesia was applying direct hot smoking method. The best type of firewood was *Laban* (*Vitex pubescens*). The smoked catfish produced by using *Laban* firewood as a smoke source showed somewhat blackish brown, shiny, dry and clay textured, and weight reduction up to 31 % of initial weight. It was the most preferred by consumers with the average of sensory value 7.4, above the minimum standard value 7.0 determined by Agency of National Standard in Indonesia for smoked fish.



(i) Volatile compounds in smoked catfish produced by using *Laban* firewood



(ii) Volatile compounds in smoked catfish produced by using *Medang* firewood



(iii) Volatile compounds in smoked catfish produced by using *Rambutan* firewood

Fig. 2. Chromatogram of volatile compounds in traditional smoked striped catfish.

It is suggested to used Laban wood as the smoke fuel and source in fish smoking, so that it became to be a characteristically type of wood for fuel and source of fish smoking in Riau Province Indonesia.

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