ISBN 978-979-792-665-6
International Proceeding

Study on The Smoking of Catfish (*Cryptopterus bicirchis*) Using The Different Kinds of Wood as The Smoke Source

Tjipto Leksono[1*], Edison[1], and M. Nur Ikhsan[2]

[1]Department of Fish Processing and Technology, Faculty of Fisheries and Marine Science
University of Riau, Pekanbaru, Indonesia
***E-mail t_leksono@ymail.com; Mobile Phone +6285234649414)**
[2]Undergraduate student at Department of Fish Processing and Technology
Faculty of Fisheries and Marine Science, the University of Riau, Pekanbaru, Indonesia

ABSTRACT

The aim of the research was to examine the use of different kinds of wood as the smoke source for catfish *selais* (*Cryptopterus bicirchis*) smoking and to determine the best typical wood used to produce smoked fish in the Rokan Hilir Regency, Riau Province, Indonesia. The woods used were *kandis* (*Garcinia xanthochymus*), *laban* (*Vitex pinnata*), *ubar* (*Eugeniasp.*) and *timah-timah* (*Elaeocarpaecae sp.*). Results shown that catfish smoking in this regency was using the direct hot smoking method. Smoked catfish produced was blackish brown, shiny, dry with clay textured. The weight reduction was up to 25% of the initial weight. The best wood used as smoke source was *ubar* (*Eugenia* sp.), but it was not significantly different from *laban* (*Vitex pinnata*). The smoked fish produced contained moisture, ash, total phenolic and acid compound 11.02%, 4.27%, 2.60%, and 0.419%, respectively.

Keywords: *catfish smoking, Cryptopterus bicirchis, smoke source, Vitex pinnata, wood.*

INTRODUCTION

The main purpose of curing the fish is to extend the shelf life of the product, but in its development smoking is also intended to obtain a certain appearance and taste of smoke in foodstuffs (Girard, 1992). While Sikorski (2005) and Visciano et al. (2008) 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. The recent developments reported by Varlet, et al. (2007) explained that the European smoked fish consumers refers more to the purpose to get the smoke flavor and aroma of the fish rather than its shelf life used liquid smoke.

The development of the production and the use of liquid smoke for food products very rapidly, it can be seen the amount of research 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 (Tranggono et al., 1996), *Vitis venivera* (Guillen and Ibargoitia, 1996), some agricultural wastes (Darmadji, 1996), *Fagus sylvatica* (Guillen and Ibargoitia, 1999), *Salvia lavandulifolia* (Guillen and Manzanos, 1999), solid wastes of spices (Darmadji et al., 1999), rubber wood (Darmadji et al., 2000), cassava wood (Hadiwiyoto et al., 2000), oak *Quercus sp*. (Guillen and Manzanos, 2002), and lamtoro wood and corncobs (Swastawati et al., 2007).

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 affectingfactors, such as types of wood or fuel material (Baltes*etal.,*1981; Magaand 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).

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 wood used as smoke fuel was also uncertain because it depended on the availability of the wood surrounding the smoking activity area. Thus, it still had not determined the typical wood as raw material of smoke fuel for cat fish *selais* (*Cryptopterus bicirchis*) smoking in Riau Province Indonesia. The process of curing the fish is 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, particularly in the application of liquid smoking method. Another problem was the content of carcinogenic compounds in smoked fish processed by applying direct hot smoking. It produced relatively higher content of the compound rather than in the smoke flavored fish, more controlled produced, by applying liquid smoking. Based on these conditions, it is necessary to investigate and determine the best type of wood as a smoke fuel to produce smoked cat fish *selais* preferred by consumers, and then using this typical wood as a raw material of liquid smoke for fish liquid smoking.

MATERIALS AND METHODS

Sample preparation. The sample used in the research was a cat fish *selais* (*Cryptopterus bicirchis*) in fresh condition, purchased from fishermen in Regency of Rokan Hulu, Riau Province Indonesia. The weight of catfish samples were225-275g each.

Smoke source. The material for smoke sources were 4 types of good wood that has been used for fish smoking, namely: wood *kandis* (*Garcinia xanthochymus*), wood *laban* (*Vitex pinnata*), wood *ubar* (*Eugenia sp.*), and wood *timah* (*Elaeocarpaceae sp*), those collected from around the smoked fish processing area. The diameter of woods was 8-12cm.They were sun-dried for several days before used.

Data analysis. The research used the methods of survey and experiment on traditionally fish smoking, to determine the effect of different types of wood used for cat fish *selais* smoking. The smoking process was conducted in Regency of Rokan Hulu in Riau Province where found many business units of cat fish *selais* smoking. Some types of wood were tried to be used to smoke the fish traditionally by applying direct hot smoking. The smoked catfish produced from the combusting of each type of wood were then brought to laboratory to be analyzed for comparing and evaluating on their differences in the sensory value and consumer acceptance of each smoked fish produced. The survey was followed by fish smoking process and 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 cat fish smoking.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 smokedfishaccordingtoSNI01-2725.1-2009(BSN,2009). Score 1 is the lowest score (extremely disliked), 5(fair)and9 is the highest score (extremely like).Moreover, it also conducted chemical evaluation to determine the water content, aw, pH, total acid content (AOAC, 2000), and total phenols (Senter et al., 1989) on the smoked fish. Each type of wood smoke material was also analyzed for their chemical composition, especially the content of lignin, cellulose and hemicellulose (TAPPI, 1991).

ISBN 978-979-792-665-6
International Proceeding

RESULT AND DISCUSSION

Fish smoking profile. There were found many catfish smoking business units in District of Rokan Hulu Riau province Indonesia. Traditional fish smoking process and the smoked catfish selais produced can be seen at Figure 1.

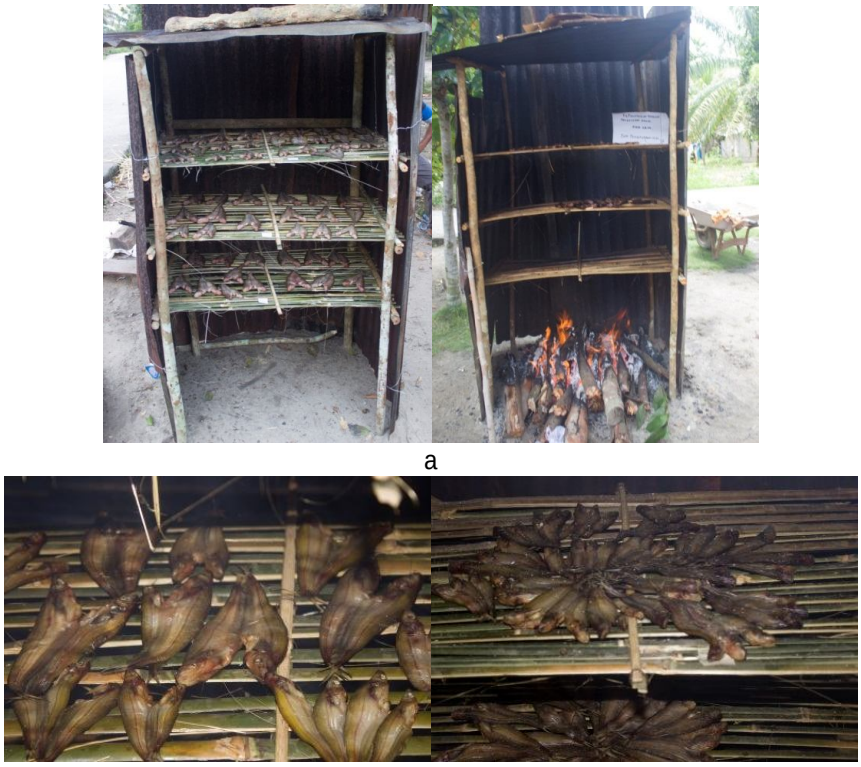

Figure1. The process of fish smoking (a) and smoked cat fish selais produced (b)

The construction of smoke house used for fish smoking in the Regency of Rokan Hilir was very simple, which was equipped with some bamboo trays where the fish was lied on. There some material wood burned below the bamboo trays to produce heat and smoke in the process of fish smoking.

The trays were inserted into the shelves in the smoking chamber, while the fire wood 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 60°C for one hour and was lowered again to 50°C for1-3 hour. The smoking process was finished when the smoked cat fish is blackish brown, shiny, dry and clay textured, and the weightwasreducedto25 % of initial weight.

Smoked cat fish 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 phenolcand acid compounds. The smoking can extend the shelf life of fish products by inhibiting the activity ofenzyme (Lakshmanan *et al*., 2003) and suppress the growth of microbes (Truelstrup*et al*., 1996; Buguenot*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).

ISBN 978-979-792-665-6
International Proceeding

Consumer preference. The result of such a slice of smoked fish with different types of wood that can be seen in Table 1.

Table 1. Sensory value of catfish *selais* (*Cryptopterus bicirchis*) smoked by using different types of wood.

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

Note: The score of the donicis ranging between 1 and 9. Score1 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)

Smoke generated from the burning of hard wood will vary with the composition of smoke produced from burning of soft wood. 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 asphenol, guaiacol and syringol and their derivatives(Kostyra and Pikielna, 2006).

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 (1979), carbonyl has the greatest effect on the formation brown in smoked fish products. Carbonyl component types that were most responsible are aldehydes glyoxal and glyoxal metal while formaldehyde and hidroksiasetol provide role lace. Phenol 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 wood*ubar,* but not significantly different to wood laban. Girard (1992) 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. Leaves (1979) explains that the phenolic compounds that play a role in the formation of the aroma of the smoke is siringol.

Flavor is a combination of stimuli tasting, aroma, and involves many organs of the tongue. Meanwhile, the taste is the character / nature of the material that produces the sensation produced by the material that goes into the mouth, taste is mainly perceived by the scent receptors in the nose and taste receptors in the mouth (Fisher and Scott, 1997).

The difference value taste in fish slice smoked allegedly as a result of the reaction between components of smoke phenol and acid that reacts with the fat on meat fish slice, this is in accordance with the opinion of Lawrie (2003), the sense given by the smoke varies, smoke the same can produce flavors different with the difference of fat in the meat. By because it taste smoked meat products somewhat dependent on the reaction between components of smoke phenols and fatty meat.

ISBN 978-979-792-665-6
International Proceeding

Texture is the sensation of pressure that can be observed by using the mouth (when bitten, chewed and swallowed), or touching with a finger to illustrate the level of density, dryness, and cohesiveness of the product are assessed (Himawati, 2010).

Physico-chemical characteristic. The data of phyco-chemical characteristic of catfish *selais* (*Cryptopterus bicirchis*) smoked by using different types of wood can be seen at Table 2.

Table 2. Phyco-chemical characteristic of catfish *selais* (*Cryptopterus bicirchis*) smoked by using different types of wood.

Type of wood	Phenols (%)	Organic Acids (%)	pH	Ash (%)	Moisture (%)
Kandis(*G.xanthochymus*)	0.744±0,001 [a]	0,74±0,20 [a]	6,52±0,19 [a]	1,88±0,02 [a]	10,77±0,09 [a]
Laban (*Vitex pinnata*)	0.745±0,002 [a]	0,92±0,35 [a]	6,51±0,10 [a]	1,90±0,03 [a]	11,26±0,08 [a]
Ubar(*Eugenia sp.*)	0.448±0,001 [a]	1,00±0,33 [a]	6,49±0,16 [a]	1,89±0,02[a]	11,24±0,01 [a]
Timah(*Eugenia sp.*)	0.741±0,002 [a]	1,13±0,20 [a]	6,51±0,09 [a]	1,77±0,02 [a]	11,26±0,04 [a]

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

Phenol is a component of the smoke that is used as one of the quality parameters in determining 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, as it is said Sutin (2008), states that the difference in the use of fumigation affects the levels of phenols in the smoke produced. Differences in levels of phenol in smoke component caused by differences in lignin content smoke source materials.

Lignin is a component of wood if decomposed will produce phenol compounds. Pengasap material directly related to the type of material consisting of hard wood or wood that can be burned, namely cellulose, hemi cellulose, lignin compounds that affect protein and mineral compounds where chemical fumes (Djatmiko et al., 1985). Meanwhile, according to WHO (1994), flavor and aroma typical of smoked fish is largely influenced by the phenol contained in wood smoke, the higher the phenol content of smoke will be stronger aroma and taste of smoked fish smoked.

The differences of total acids content in each treatment allegedly because of differences in the content of hemi cellulose and cellulose on the type of wood used as a source of the smoke. Sutin (2008) states that 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 (Sutin, 2008). 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 (Astuti, 2000).

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.

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 ofthe 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

Determination of the pyrolysis temperature of 350 ºC because, according to Girard (1992), the components of cellulose produces organic acids and components of wood such as lignin decomposes produce phenol, guaiacol and so on. If the temperature exceeds or above the temperature used, then what happened is the cooking process and remove tar charcoal is very high. Darmadji (1996) that produce liquid smoke from agricultural waste with a temperature of 400 ° C at a time for approximately 1 hour.

The highest yield of liquid smoke produced from the results of this study are liquid smoke from wood *laban*. This 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, H_2, CH_4 and some hydrocarbons.

Sjostrom (1995), said in conventional pyrolysis processes to produce the most important is the solid charcoal, but also varying amounts of gas formed and tar. Gases which can not 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, ie between 100ºC - 150º C. At these temperatures occur evaporation process that separates compounds of organic acids and phenolic compounds in the liquid smoke. (Darmadji, 2002).

ISBN 978-979-792-665-6
International Proceeding

CONCLUSION

The smoking of catfish *selais* (*Cryptopterus bicirchis* in Riau Province Indonesia was conducted traditionally by applying direct hot smoking methods. the smoked cat fish is 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.

REFERENCES

(BSN) National Agency of Standardization in Indonesia, 2009. Indonesia National Standard on Fish Smoking, SNI 2725.1:2009. Jakarta. (In Indonesian)

Afrianto, E. dan E. Liviawaty, 2005. Fish Preserving and Processing. 14th eds. Published by Kanisius, Yogyakarta. Pp. 67-77 (In Indonesian)

AOAC, 1995. Official Methods of Analysis of the Association of Official Analytical Chemist: 16th ed. Edited by Patricia Cunniff. Arlington.

AOAC, 2000.Official Methods of Analysis of Association of Official Analytical Chemists International. 17th ed. Edited by Horwitz W. Gaithersburg Maryland.

Apriyantono, A., Fardiaz, D., Puspitasari, N.L., Sedanarwati, Budianto, S., 1989.Laboratory Manual of Food Analysis. Inter-University Centre. IPB Bogor. (In Indonesian)

Baltes, W., Wittkowski, R., Sochtig, I., Block, H., and Toth, L., 1981.In G. Charalambous and G. Inglett (Editors).The Quality of Food and Beverages, Academic Press, New York. Vol. 2 : 1-14

Belitz, H.D. and W. Grosch, 1987.Food Chemistry. Springer-Verlag Berlin, Heidelberg, Germany. Pp. 372-441

Bugueno, G., I. Escriche, N. Martínez-Navarrete, M.M. Camacho, A. Chiralt, 2003. Influence of Storage Conditions On Some Physical and Chemical Properties of Smoked Salmon (*Salmo Salar*) Processed by Vacuum Impregnation Techniques. J. Food Chemistry, 81 (1): 85-90

Cardinal, M., Cornet, J., Serot, T., R. Baron, 2006. Effects of the smoking process on odour characteristics of smoked herring (*Clupea harengus*) and relationships with phenolic compound content. J. Food Chemistry, 96: 137 - 146.

Daun, H., 1979, Interaction of Wood Smoke Components and foods, J. Foods Tech., 33 (5) : 67 – 71.

Fuentes A., Fernandez, I.S., Barat, J.M., and Serra, J.A., 2010.Physicochemical Characterization of Some Smoked and Marinated Fish Product.J. Food Processing and Preservation. 34:83-103

Ghozali, Thomas, D. Muchtadi, and Yaroh, 2004.Shelf life Increasing of of Milkfish(*Chanos Chanos*) *Sate*Stored in ColdandFreezing Preserving System. Infomatek, 6 (1): 51-66. (In Indonesian).

Girard, J.P., 1992. Smoking *in* Technology of Meat Products.Translated by Bernard Hammings and ATT, Clermont Ferrand. New York. Ellis Harwood, pp 165-205

Guillen, M.D. dan M.L. Ibargoitia. 1999. Influence of the moisture content on the composition of the liquid smoke produced in the pyrolysis process of *Fagus sylvatiea* L. wood. J. Agriculture and Food Chemistry,47:4126-4136.

Hattula, T., K. Elfving, U.M. Mroueh, T. Luoma 2001.Use of Liquid Smoke Flavouring as an Alternative to Traditional Flue Gas Smoking of Rainbow Trout Fillets (*Oncorhynchus mykiss*). J. Lebensmittel-Wissenschaft und-Technologie, 34(8): 521-525

Kostyra, E. and N. Baryłko-Pikielna, 2006. Volatiles Composition and Flavour Profile Identity of Smoke Flavourings. J. Food Quality and Preference, 17: 85–95

Lakshmanan, R., J.R., Piggott, and A. Paterson, 2003.Potential Applications of High Pressure for Improvement in Salmon Quality.Trends in Food Science and Technology, 14: 354-363.

Leksono, T, Padil, and Aman, 2009.Application of Liquid Smoke Made of Oil Palm Shell on Fresh-Water Catfish (*Pangasius hypopthalmus*) Preservation. Proceeding International Seminar: "*From Ocean for Food Security, Energy, and Sustainable Resources and Environment*". Airlangga University Surabaya, 18 November 2009.

Maga, J. A. and Z. Chen, 1985. Pyrazine composition of wood smoke as influenced by wood source and smoke generation variables. Flavour and Fragrance Journal, 1(1): 37–42

Maga, J.A., 1988. Smoke in Food Processing. CRC Press, Boca Raton, Florida. Pp. 89-91; 99-138

Martinez, O., J. Salmeron, M.D. Guillen, and C. Casas, 2007.Sensorial and Physicochemical Characteristics of Salmon (*Salmo salar*) Treated by Different Smoking Processes during Storage. J. Food Science and Technology International, 13(6): 477-484.

Muratore G., Mazzaglia, A., Lanza, CM, and Licciardello, 2007. Effect of Process Variables on the Quality of Swordfish Fillets Flavoured with Smoke Condensate. J. Food Processing and Preservation, 31 (2): 167-177

Murniyati, A.S. and Sunarman, 2000.Refrigeration, Freezing dan Preservation of Fish. Kanisius Pub. Yogyakarta. P.83. (In Indonesian)

Obodai, E.A., Muhammad, B.A., Obodai, G.A., and Opoku, E., 2009. Effect of Fuel wood on the Quality of Smoked Freshwater Fish Species Sold in Tamale. Ethiopian Journal of Environmental Studies and Management, 2 (2): 27-35

Pszczola, D.E., 1995, Tour Highlights Production and Uses of Smokes Based Flavours. Journal of Food Technology, 49 (1): 70 – 74.

*Ruiter,*A.,*1979.Colour of Smoked Foods.* J. *Food* Technology, 33:(5) 54-63

Senter, S.D., J. A. Robertson, and F. I. Meredith, 1989. Phenolic Compound of The Mesocarp of Cresthaven Peaches During Storage and Ripening. J. Food Sciences 54: 1259-1268.

Sikorski, Z.E., 2005. The Effect of Processing on the Nutritional Value and Toxicity of Foods. In: Toxins in Food. CRC Press, Boca Raton. Florida Pp. 303-311.

Storey, R.M., 1982.Smoking.*In* Fish Handling and Processing. 2nd Ed. Editors: A. Aitken, I.M. Mackie, J.H. Merritt and W.L. Windsor, Torry Research Station Ministry of Agriculture, Fisheries and Food. Edinburgh. Pp. 98-114

Swastawati, F., E. Susanto, B. Cahyono, and W.A. Trilaksono, 2012.Sensory Evaluation and Chemical Characteristics of Smoked Stingray (*Dasyatis blekeery*) Processed by Using Two Different Liquid Smoke.International Journal of Bioscience, Biochemistry, and Bioinformatics. 2 (3): 212-216.

Swastawati, F., Soedibjono, D.A.S. Dita, 2008. Physicochemical Changes in Milk Fish (*Chanos chanos* Forks) Boneless Treated with Maize Cob and Coconut Shell Liquid Smoke. International Conference, Geomatic, Fisheries and Marine Science for a Better Future and Prosperity. Semarang

Tongco, M.D.C., 2007. Purposive Sampling as a Tool for Informant Selection. J. Ethnobotany Research & Applications 5:147-158

Toth, L. dan K. Potthast, 1984.Chemical Aspects of the Smoking of Meat and Meat Products. Advances in Food Research 29: 87-158.

Truelstrup, L.H, Tom Gill, Drewes, S.R. and H.H. Huss, 1996.Importance of Autolysis and Microbiological Activity on Quality of Cold-Smoked Salmon. Food Research International, 29 (2): 181-188

Turan, H., Sonmez, G., Celik, M., Yalcin, K. and Yalcin, M. (2008). The Effects of Hot Smoking on The Chemical Composition and Shelf Life of Mediterranean mussel (*Mytilus galloprovincialis*) under Chilled Ctorage. Journal of Food Processing and Preservation,32, 912–922

Varlet, V., T. Serot, C. Knockaert, J. Cornet, M. Cardinal, F. Monteau, B. Le Bizec, and C. Prost, 2007.Organoleptic Characteristic and PAH Content of Salmon (*Salmo salar*) Fillets Smoked According to Four Industrial Smoking Techniques. Journal of the Science of Food and Agriculture, 87 (5): 847 -854

Visciano, P., M. Perugini, F. Conte, M. Amorena, 2008. Polycyclic Aromatic Hydrocarbons in Farmed Rainbow Trout (*Oncorhynchus mykiss*) Processed by Traditional Flue Gas Smoking and by Liquid Smoke Flavourings. J. Food and Chemical Toxicology, 46 (5): 1409-1413

Winarno, F.G., 1993. Food, Nutrition, Technology and Consumers.PT Gramedia Pustaka Utama Pub. Jakarta. (In Indonesian)

Woody, M.W., G.J. Flick Jr., R.E. Martin, and A.I. Correa, 2000. Smoked, Cured, and Dried Fish, in Marine and Freshwater Products Handbook, Edited by R.E. Marten, E.P. Carter, G.J. Flick Jr., and L.M. Davis. Technomic Publishing Co., Inc, Lancaster USA. Pp. 381-401.