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Volatile flavor compounds composition of fresh and steamed tiger shrimp (*Penaeus monodon*)

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Abstract

The objective of this study were to identify fresh and steamed tiger shrimp volatile compounds. Tiger shrimp was taken from Indramayu, West Java, subsequently the sample preparation was conducted at the Laboratory of Fishery Processing Technology, Faculty of Marine Science, University of Padjadjaran. Volatile components were analyzed at Flavor Laboratory, Indonesian Center for Rice Research, Sukamandi, Subang in February to April 2018. The methods use was experimental with two different treatments consist of fresh and steamed tiger shrimp. Volatile compounds were analyzed using Gas Chromatography / Mass Spectrometry (GC / MS) with extraction temperature of 45ºC for fresh sample and 80ºC for steamed sample in 45 minutes (Solid Phase Micro Extraction). The proximate analysis was analyzed at Inter-University Centre Laboratory, Bogor Agricultural Institute. The volatile compound analysis successfully detected 27 compounds in fresh samples and 36 compounds in steamed tiger shrimp sample. The proximate analysis showed variances between the two treatments especially on moisture content, ash, protein, and lipid (Fresh black tiger shrimp had 77.42% moisture content, 1.55% ash, 0.59% lipids, 19.96% protein and steamed tiger shrimp had 67.37% moisture content, ash 1.56%, 1.06% lipids and 29.31% protein).

Keywords: tiger shrimp, flavor, volatile, proximate

1. Introduction

Fisheries subsector is one of the major source of food and nutrition intake in Indonesia. One of many popular fisheries commodities in Indonesia is shrimp which has high economic value due to it is considered as main export commodity (Guslan 2016) [8]. One type of shrimp that is commonly found in Indonesia is tiger shrimp (*Penaeus monodon*). The results of tiger shrimp production in Indonesia from 2010-2014 increased by 3.32% (DPJB 2015) [4]. Shrimp is raw materials for many foodstuffs which contain active compounds which beneficial to human health, growth and development of the human body (Ngginak *et al*. 2013) [14]. Shrimp as supporting food needs is very clear. This is known through the presence of various kinds of processed shrimp products that are processed and marketed (Trung *et al*. 2012) [22].

The processing of food by heating process can be carried out in various ways. According Gardjito (2013) [6], one example of processing with high temperatures is by means of steam (wet heating). Steaming or the use of steam as a heat source has the advantage of minimizing the loss of vitamins and other dietary components which are sensitive to heat (Fellows 2000). Steaming as one form of treatment using high temperature is expected to affect the composition of flavor compounds in fishery products (Pratama *et al*., 2013) [15].

Flavor is one of the important factors to the acceptance of a food in the community. Flavor is generally composed of volatile flavor compounds which derived from various groups of compounds such as alcohols, ketones, aldehydes, certain compounds which contain sulphur and nitrogen, hydrocarbons, heterocyclic compounds, and esters (Tanchotikul & Hsieh 1989 in Liu *et al*, 2009) [21, 11]. Volatile components are flavor components that act as aromas perceived by aroma receptors from olfactory organs such as olfactory tissue in the nasal cavity. Taste molecules (which are nonvolatile) are released from food into the oral cavity and volatile flavor components move through the nasopharynx in the nose when food is eaten (Pratama 2011) [15]. The purpose of this study is to study and identified volatile compounds composition found in fresh and steamed tiger shrimp.

2. Research Method

2.1 Preparation Procedures

A 3 kg shrimp sample was taken from Karangsong fish landing site, West Java using a cool box by giving a 5 cm thick layer of ice cubes to prevent the propagation of heat from the air on the outside. Thickness between layers of shrimp and ice should be the same and try to keep each shrimp covered with ice so that it cools faster, then on the edge, a layer of ice as thick as 7 cm was added (Suprayitno 2017). Coolbox which already contains samples of shrimp brought to the Laboratory of Fishery Products Processing UNPAD to be prepared.

Shrimp is divided into two groups of 250 g each. The preparation process for the fresh treatment including cleaning and washing the shrimp then shelled and the head is peeled, after that the tiger shrimp meat is packaged using aluminum foil, cling wrap and put into zip-lock plastic. The preparation process for the steamed shrimp treatment consist of washing and then steaming using a temperature of 100ºC, subsequently, the shell and head are removed, the shrimp meat is then packed, with the same packaging method as packaging in a sample of fresh shrimp treatment. Each package must be marked using label paper. The three layered packaging step is done to minimize changes and damage to the flavor of the sample to be analyzed. These changes and damage can be caused by air, light, and temperature (Pratama 2011) [15]. The packaged samples are put in a low temperature cool box to be transported to the associated laboratory to be analyzed for their volatile compounds and proximate composition.

2.2 Analysis Procedures and Data Analysis

Proximate analysis performed on samples of fresh and steamed tiger shrimp includes water, ash, protein and lipid content based on the AOAC (2005) [1] procedure. The procedure for analyzing volatile compounds carried out is a modification of the procedure carried out in the study of Guillen & Errecalde (2002) [9]. Analysis of volatile compounds was carried out using a series of Gas Chromatography (Agilent Technologies 7890A GC System) and Mass Spectometry (Agilent Technologies 5975C Inert XL EI CI / MSD) apparatus. Sample extraction was carried out using the Solid Phase Microextraction (SPME) method using DVB / Carboxen / Poly Dimethyl Siloxane fiber with a heating temperature of 40oC for fresh sample and 80oC for steamed sample in 45 minutes (in a waterbath). The GC column used is HP-INNOWax (30m x 250µm x 0.25µm), helium carrier gas, initial temperature 45 ℃ (2-minute hold), increase in temperature 6 ℃ / minute, final equipment temperature 250 ℃ (hold 5 minutes) for 45 minutes. The spectra of the detected compound mass were compared to the mass spectra patterns found in the data center or the NIST version 0.5a library (National Institute of Standard and Technology) in computer databases. The data of the volatile flavor compound components were analyzed further using the Automatic Mass Spectral Deconvolution and Identification System (AMDIS) software (Mallard and Reed 1997) [13]. Data from the analysis of volatile compounds produced will be discussed descriptive comparatively based on the identification and intensity of semi-quantification of compounds detected in the samples tested (Pratama 2011) [15]. Data obtained from the proximate analysis of all samples were calculated by the average value and standard deviation based on Steel and Torrie (1983) [19], then discussed descriptively.

3. Results and Discussion

3.1 Analysis of Volatile Compounds

The analysis results of tiger shrimp (*Penaeus monodon*) volatile flavor compounds showed that there are 27 volatile compounds in fresh shrimp sample (Table 1) and 36 volatile compounds in the steamed shrimp sample (Table 2). More compounds detected in the steamed sample rather than the fresh one. Volatile flavor compounds identified can be categorized into several major categories of compounds such as hydrocarbons, aldehydes, alcohols, ketones and their derivatives

Table 1: Volatile compounds identified in fresh tiger shrimp

No.	Group	RT	Compound	Area	Proportion (%)
1	Hydrocarbons	14.4162	Limonene	204300	2.529852
2		14,438	Toluene	219217	2.714570
3		14.9038	Cyclohexene, 1-methyl-4- (1-methylethenyl) -, (S) -	217950	2.698881
4		15.8554	1,3,6-Heptatriene, 5-methyl-	16450	0.203701
5		18 382	Naphthalene	126865	1.570973
6		22.5368	Hexadecane	96388	1.193575
7		24.5167	Pentadecane	99073	1.226824
8	Aldehyde	8.9963	Hexanal	14145	0.175158
9		11.2691	Heptanal	21287	0.263597
10		11.7591	Benzaldehyde, 4-ethyl-	69520	0.860868
11		13.6009	Benzaldehyde, 4-ethyl-	288532	3.572899
12		13.7119	Octanal	14919	0.184742
13		16.1346	Nonanal	180090	2.230059
14	Alcohol	5.1846	1-Penten-3-ol	906463	11.224756
15		9.2496	Silanediol, dimethyl-	4311730	53.392268
16		13.2213	1-Octen-3-ol	71854	0.889770
17		15.4244	1-Octanol	5417	0.067079
18		15.4345	1-Nonanol	33870	0.419413
19		15.4475	1-Heptanol	7363	0.091176
20		16.1529	2-Penten-1-ol, (Z) -	69405	0.859444
21		18.4764	2-Hexen-1-ol, (E) -	60489	0.749037
22	Ketones	20.4068	2-decanone	361	0.00447
23		20.4245	3,5-Octadien-2-one	370155	4.583639
24		21.4612	2-Heptanone	11456	0.14186
25	Others	6687	Methylamine, N, N-dimethyl-	5228	0.0647385
26		12.1186	Oxime-, methoxy-phenyl-_	631107	7.8150149
27		20.2864	Furan, 2-pentyl-	21936	0.2716341

Table 2: Volatile compounds identified in steamed tiger shrimp

No.	Group	RT	Compound	Area	Proportion (%)
1	Hydrocarbons	14.4368	Limonene	45532	0.432
2		15.8908	Octane, 2-methyl-	2725	0.026
3		22 529	Undecane	1630	0.015
4		24 522	Pentadecane	9642	0.092
5		26 391	Tetradecane	14153	0.134
6		28.1638	Tetradecane	149719	1.421
7		28.2936	Hexadecane	45046	0.428
8		34.5216	Toluene	2358	0.022

9	Aldehyde	8.3269	Pentanal	164 192	1.559
10		13.6292	Octanal	1737	0.016
11		16.0992	nonanal	5097	0.048
12		17.3111	2,4-Heptadienal, (E, E) -	175705	1.668
13		20.2811	Butanal	10230	0.001
14		20.4109	4-Heptenal	14703	0.140
15		27.8172	2-Octenal, (E) -	38133	0.362
16		30.2358	Hexadecanal	3813719	36.203
17		30.2358	Dodecanal	665774	6.320
18		31.8633	2-Pentenal, (E) -	44447	0.422
19		31.8805	2-nonenal, (E) -	817	0.008
20	Alcohol	5.0889	2-Penten-1-ol, (E) -	1087	0.114
21		13.1215	1-Penten-3-ol	5906	0.056
22		18.4652	2-Penten-1-ol, (Z) -	1529	0.015
23		20.2799	1-Octanol	8839	0.084
24		22.5414	1-Octen-3-ol	57139	0.542
25		22.8189	1-Pentanol	6345	0.060
26		24.3779	1-Heptanol	2616	0.025
27		24 829	1-Hexanol, 2-ethyl-	10164	0.096
28		26.7086	2-Octen-1-ol	1498	0.014
29		31.2742	1-Nonanol	724888	6.881
30	Ketones	14,438	2,3-Octanedione	2377	0.023
31		17 284	(+) - 2-Bornanone	50942	0.484
32		17.9333	3,5-Octadien-2-one	19780	0.188
33		18.2344	3-Heptanone, 6-methyl-	11751	0.112
34		20.3985	2-Heptanone	851	0.008
35	Others	24.5427	Furan, 2-pentyl-	4256363	40.405
36		26.4181	Methylamine, N, N-dimethyl-	166712	1.583

Aldehyde compounds, alcohols, ketones, acids and hydrocarbons are the main volatile compounds in fishery products and free amino acids, nucleotides and peptides are the main nonvolatile compounds (Liu *et al*. 2009) [11]. Fresh tiger shrimp has fewer volatile compounds than steamed tiger shrimp. According to Pratama *et al*. (2013) [15] in general it can be said that steamed samples will have more volatile amounts than fresh samples. The process that involves heat such as steaming is one of the factors affecting the volatile compounds identified.

The identified volatile flavor compounds in both samples consisted of several major groups. The hydrocarbon group in fresh tiger shrimp sample consists of 7 compounds and in the steamed tiger shrimp sample consists of 8 compound. The highest proportion compounds in hydrocarbon group of fresh shrimp is toluene (2.71%) and the highest compound proportion in steamed sample is tetradecane (1.42%). According to ATSDR (2017) [2] the main use of toluene is as a mixture added to gasoline to increase the octane rating. Toluene is also used to produce benzene and as a solvent in paints, coatings, synthetic fragrances, adhesives, inks, and cleaning agents. Toluene was identified in fresh shrimp, the possibility of this compound originating from water pollution that occurs in the waters where tiger shrimp is captured. According to Yannai (2003) [23], tetradecane compounds are flammable colorless liquids, usually used in paraffin manufacturing, paper processing industries, jet fuel research, and the rubber industry. In the study of Liu *et al* (2009) [11] tetradecane compounds were also found in samples of fresh and steamed Silver Carp. According to Liu (2009) [11] most hydrocarbons usually show a relatively high threshold, but the hydrocarbon compounds identified in the sample at high amounts can play a role in the overall flavor of the product.

The aldehyde group identified in the fresh tiger shrimp sample consist of 6 compounds, while 11 compounds identified in steamed sample. 4-ethyl-benzaldehyde compound is the compound with the largest proportion (3.57%) in fresh tiger shrimp, whereas in the steamed sample, hexadecanal has the highest proportion (36.20%). Benzaldehyde is also known to be an important flavor in freshwater lobster meat, turbot fish, salmon and fish feed (Tanchotikul & Hsieh 1989; Linder & Ackman 2002) [21].

The alcohol group identified in the fresh tiger shrimp sample consist of 8 compounds. The dimethyl-silanediol compound has the largest proportion of all identified compounds in the fresh sample (53.39%). Dimethyl-silanediol compounds enter the environment through waste water (Ministry of Environment of the Czech Republic 2015). The dimethyl-silanediol compound is also said to be the main contaminant in water (Ramanathan *et al*. 2012) [17]. According to Girard and Durance (2000) [7] a group of alcohol compounds are generally formed by decomposition and secondary hydroperoxide from fatty acids. The alcohol group in the steamed shrimp samples contained 10 compounds, but each compound had a small proportion on average below 1% except the 1-nonanol compound with a proportion of 6.881%.

The ketone group identified in the sample of fresh shrimp consisted of 3 compounds, with 3, 5-octadien-2-one (4.58%) has the highest compound proportion. Steamed sample has 5 ketones group compounds with (+)-2-Bornanone (0.48%) has the highest compound proportion. According to Yannai (2003) [23] this compound is white in color and fragrant According to Pratama (2011) [15], ketones are mostly known to be in volatile substances and are likely to result from oxidation of fats (especially unsaturated fatty acids) during heating, in addition to that, thermal degradation, amino acid degradation and Maillard reactions are all possible mechanisms for ketone component formation.

2-penthyl furan compound is the compound that has the highest proportion of all compounds which detected (40.405%) in steamed shrimp samples. According to Maga (1987) furan represents a type of heterocyclic component containing five oxygen, this compound probably originates from dehydration of glucose which is then an intermediary of thermal degradation of cellulose. The 2-penthyl furan compound is a typical product of lipid oxidation (Guillen & Errecalde 2002) [9]. According to Tanchotikul and Hsieh (1989) [21], 2-penthyl furan compounds are known to also exist in freshwater lobster wastes and these compounds impart flavor to cooked meat.

3.2 Proximate analysis

Proximate analysis also performed in this study. The shrimp has a high nutrient content, but the process involving thermal processing in general can lead to decreased nutrient content in shrimp. Reduced nutrient content in food may result from thermal processes (Fellows 2000) [5]. The chemical composition of fresh and steamed tiger shrimp can be seen in Table 3.

Table 3: Proximate analysis samples tiger shrimp fresh and steamed

Samples	Moisture (%)	Ash (%)	Lipid (%)	Protein (%)
Fresh shrimp	77.42 ± 0.08	1.55 ± 0.01	0.59 ± 0.01	19.96 ± 0.07
Steamed shrimp	67.37 ± 0.01	1.56 ± 0.47	1.06 ± 0.13	29.31 ± 0.01

The analysis results (Table 3) show the tiger shrimp chemical composition experiencing variation in decreases and increases its value after the steaming process. Moisture content decreased from 77.42% in fresh sample to 67.37% in steamed sample, ash content increased from 1.55% to 1.56%, lipid content increased from 0.59% to 1.06%, and protein content increased from 19.96 % to 29.31%.

The decrease in water content occurred in fresh and steamed tiger shrimp from 77.42% to 67.37%. According to Pratama *et al*. (2013) [15] the difference in water content that occurred in the sample studied was influenced by the initial moisture content of the raw material, the type of commodity tested and the subsequent processing steps. According to Zaitsev *et al*. (1969) in Jacoeb *et al*. (2008) [10] high temperatures can cause protein coagulation, so that the water released is greater. According to Fellows (2000) processing with hot steam can cause a loss of water content from the space between cells.

The analysis results of in Table 3 show that ash content increased by 0.01% in steamed tiger shrimp. Dayal *et al*. (2007) [3] stated that minerals commonly contained in shrimp include calcium, magnesium, phosphorus, potassium, sodium, copper, iron, manganese, selenium, and zinc. Some of these minerals will experience ignition at a temperature of 550 ℃ so that the steaming temperature (90-100 ℃) does not have a significant effect on the ash content between samples of fresh and steamed tiger shrimp.

The analysis results in Table 3 show higher lipid content measured in steamed shrimp compared to fresh shrimp. Lipid content of tiger shrimp increased by 0.5% in steamed tiger shrimp. According to Pratama *et al*. (2013) [15] the higher the water content that comes out during the steaming process of the sample, the higher the measured amount of lipid in sample.

The analysis results in Table 3 show a fairly high increase in steamed sample protein level compared to fresh tiger shrimp sample. According to Pratama *et al*. (2013) [15] the steaming process can affect changes in protein properties in steamed samples even though the changes are not as large as those given by heating samples using higher temperatures. The measured protein content is also influenced by the water content contained in the material where a low water content will produce higher protein levels measurement (Sebranek 2009) [18].

Conclusion

More volatile compounds detected in steamed tiger shrimp samples compared to fresh one. Volatile compounds detected in fresh shrimp is 27 compounds and 36 compounds in steamed tiger shrimp samples. The group of compounds detected can be categorized into hydrocarbon groups, aldehyde groups, alcohol groups, ketone groups, and other groups. The alcohol group is the group that dominates fresh shrimp samples because 8 compounds are identified and one of them is dimethylsilanediol compounds which has the largest proportion of 53.39%. The 2-penthyl furan compound is a compound from the other groups which has the largest proportion of steamed shrimp samples which is 40.405% compared to 35 other identified compounds.

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