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Composition of volatile flavor compounds from mackerel head broth and mackerel bone broth, *Scomberomorus commerson* (Lacepède, 1800)

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ABSTRACT

Mackerel of *Scomberomorus commerson* (Lacepède, 1800) is a fish that has thick meat of a distinctive taste and is a favorite of Indonesian people. It is made into various types of processed seafood. The amount of edible flesh of the fish is 65%, meaning that the waste from the fish is 35%, including the head and bones. The purpose of this study was to determine the type and class of volatile compound components that can be drawn from mackerel head and fish bone, by making these into a broth. This study uses an experimental method by testing the composition of volatile flavor compounds and then undertaking proximate testing. The method of extracting volatile flavor compounds that was applied is Solid Phase Microextraction (SPME), while Gas Chromatography / Mass Spectrometry (GC / MS) was harnessed to identify the volatile flavor. Accordingly, 150 compounds were detected in the sample of mackerel head broth, as compared with 133 compounds in mackerel bone broth. The compounds that were detected are hydrocarbons, aldehydes, alcohols, ketones, organic compounds and others. That which has the largest proportion is pentadecane from the hydrocarbon group, with a value of 18,545%. The proximate analysis results showed that mackerel head broth samples had a 96.08% water content, 1.55% ash content, 0.28% fat content and 2.78% protein content, while samples of mackerel bone broth had a 96.69% water content, 1.54% ash content, 0.44% fat content and 1.84% protein content.

***Keywords*:** Broth, Solid Phase Microextraction, volatile flavor compounds, proximate, *Scomberomorus commerson*

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1. INTRODUCTION

Indonesian fisheries have a promising fishery potential. The total national fisheries production in 2017 is 23.26 million tons and capture fisheries 6.04 million tons per year. Based on data from the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, the volume of capture fisheries production in the sea, specifically mackerel fish species in 2016 amounted to 225,936 tons and in 2017 increased by 438,658.17 tons. In general, in Indonesia, mackerel fish are widely used by food processing industries. Processing of fishery products produces waste, such as heads, innards, scales, fins, skin and bones. According to the Indonesian Department of Maritime Affairs and Fisheries in 2005, fisheries commodity exports in the form of fillets, so that the bones become waste in the fishing industry.

Mackarel fish is a fish that has thick meat which is a favorite of Indonesian people to be made into various types of processed seafood with a distinctive flavour. Mackerel fish has a very high nutrient content, good taste and affordable prices. Mackerel fish contains high quality protein, vitamins and omega 3 which are very useful for growth and endurance.

Figure 1. *Scomberomorus commerson* (Lacepède, 1800)

Flavor is a sensation that appears and is caused by volatile or non-volatile chemical components, which come from natural or synthetic, and arise when eating or drinking. Volatile components are components that provide a smell sensation, give an initial impression, and evaporate quickly. Non-volatile components give a sensation to taste, which is sweet, bitter, sour, and salty.

One of the flavors formed from food is by processing or storing. Boiling is the process of flavor formation through processing. Flavor compounds contained in fish are usually derived from derivatives of protein compounds and mostly fat. The composition of flavor volatile compounds detected in fishery products usually comes from groups of aldehydes, alcohols, ketones and hydrocarbons. The purpose of this study was to determine the type and class of components of volatile compounds identified from the head and mackerel fish bone by making it into a broth.

Taxonomic Hierarchy

1. Animalia (Kingdom)
2. Chordata (Phylum)
3. Vertebrata (Subphylum)

4. Gnathostomata (Superclass)
5. Pisces (Superclass)
6. Actinopterygii (Class)
7. Perciformes (Order)
8. Scombroidei (Suborder)
9. Scombridae (Family)
10. Scombrinae (Subfamily)
11. *Scomberomorus* Lacepède, 1801 (Genus)
12. *Scomberomorus commerson* (Lacepède, 1800) (Spesies).

2. MATERIALS AND METHODS

The research was conducted from January to April 2019. Sampling of mackerel fish was carried out in Karangsong, Indramayu, West Java. Sample preparation was carried out at the Fisheries Product Technology Laboratory, Padjadjaran University. Chemical analysis was carried out at the Laboratory of Endangered Animal and Hope Conservation of the Integrated Laboratory, Bogor Agricultural Institute and Flavor Laboratory of the Center for Rice Research, Sukamandi, Subang, West Java. The tools used include a knife, cutting board, aluminum foil, cling wrap, stove, steamer pan, analytical scales, label, coolbox, waterbath, and gas chromatography / mass spectrometry.

The materials used include mackerel, ice cube, H_3BO_3, $CuSO_4$, HCl, H_2SO_4, H_2O_2, K_2SO_4, and NaOH. The procedure of the research starts from the preparation of fish, weeding, washing clean, separating meat from bones and head, making fish head broth, making fish bone broth, and wrapping in sample containers. After preparation, the packed sample is put in a coolbox containing ice with low temperature to be transported to each analysis laboratory. Analysis of volatile compounds was carried out using a series of Gas Chromatography (GC) and Mass Spectrometry (MS) devices.

Sample extraction was carried out using the Solid Phase Micro Extraction (SPME) method using DVB / Carboxen / Poly Dimethyl Siloxane fiber. The GC/MS tool is operated for 30 minutes and then after the result will appear the results in the form of a chromatogram, the compounds detected in the sample and possibly other compounds. The mass spectra of the detected compounds were then compared with mass spectra patterns found in the data center or the NIST version 0.5a library (National Institute of Standard and Technology) on computers.

3. RESULT

The results of the analysis of volatile compounds using Gas Chromatography / Mass Spectrophotometry succeeded in identifying volatile compounds that were identified in 150 mackerel fish stew samples and in 133 samples of mackerel fish stew water.

The results of the analysis of volatile compounds using Gas Chromatography / Mass Spectrophotometry broadly indicate that the detected compounds are compounds from the hydrocarbon group, aldehydes, alcohols, ketones, organic compounds and others **Table 1**.

Table 1. The results of the analysis of volatile compounds of mackerel head broth

Group	RT (min)	Compound	Area	Propotion
Hydrocarbon	23.277	pentadecane	352377886	14.639
	27.8733	heptadecane	88279359	3.668
	28.0041	heptadecane, 2,6-dimethyl-	48856648	2.030
	14.59	1-nonene	37728600	1.567
	17.3429	1,4-octadiene	29793628	1.238
	19.8581	tridecane, 2-methyl-	27778116	1.154
	12.2413	cyclopentane, ethyl-	17196111	0.714
	19.977	cis,cis- and cis,trans-1,9-dimethylspiro[4.5]decane	13900645	0.577
	20.4646	cyclotetradecane	11485739	0.477
	22.6824	cyclopropane, nonyl-	8616156	0.358
	13.3889	2-hexene, 3-methyl-, (Z)-	8406244	0.349
	15.2797	dodecane	8195744	0.340
	13.4959	cyclopropane, 1,1-diethyl-	6337802	0.263
	13.1332	4-nonene	6322872	0.263
	12.7765	octane, 4-methyl-	6274319	0.261
	22.7597	1,2-di-but-2-enyl-cyclohexane	6192373	0.257
	15.8029	cyclohexene, 1,2-dimethyl-	6189341	0.257
	16.8138	2,6-octadiene-1,8-diol, 2,6-dimethyl-	6062928	0.252
	12.937	cyclohexane, 1,2,3-trimethyl-	6026508	0.250
	19.6143	tridecane, 4-methyl-	6008848	0.250
	20.7143	tetradecane	5682751	0.236
	27.3738	cyclotetradecane	5247733	0.218
	3.8991	2-hexene, (E)-	4591756	0.191
	23.8657	3-hexene, 3,4-dimethyl-, (Z)-	4438739	0.184

Group	RT (min)	Compound	Area	Propotion
	15.9754	cyclohexane, 1,2,4-trimethyl-	4244514	0.176
	22.0046	cyclopentane, 1,1,3,3-tetramethyl-	4034263	0.168
	14.9884	naphthalene	3981278	0.165
	10.3624	bicyclo[5.2.0]non-1-ene	3694059	0.153
	22.2841	undecane	3455630	0.144
	24.7814	dodecane	3237082	0.134
	16.4986	cyclotridecane	2982452	0.124
	22.3911	allo-aromadendrene	2434560	0.101
	24.1868	hentriacontane	2366895	0.098
	21.41	caryophyllene	2294386	0.095
	7.9424	1,3-pentadiene, 2,4-dimethyl-	2266137	0.094
	21.3387	caryophyllene	2102011	0.087
	28.236	naphthalene, 1,2,3-trimethyl-4-propenyl-, (E)-	2023312	0.084
	17.5154	1-methyl-2-methylenecyclohexane	1945218	0.081
	16.4332	cyclopentane, 1-pentyl-2-propyl-	1658440	0.069
	30.0079	nonadecane	1350343	0.056
	25.257	cetene	1301588	0.054
	23.6754	butylated hydroxytoluene	852936	0.035
	26.8981	cyclotetradecane	832221	0.035
	27.5046	2,6-diisopropylnaphthalene	707565	0.029
	28.89	octadecane	628129	0.026
	28.4381	2,6-diisopropylnaphthalene	584229	0.024
	27.6117	1,7-di-iso-propylnaphthalene	571918	0.024
	28.5273	1,4-di-iso-propylnaphthalene	511396	0.021
	29.3836	trans-1,2-diphenylcyclobutane	378227	0.016

Group	RT (min)	Compound	Area	Propotion
	28.789	1,7-di-iso-propylnaphthalene	341219	0.014
Alcohol	9.0424	1-octen-3-ol	90835169	3.774
	6.117	1-hexanol	67258604	2.794
	4.4521	silanediol, dimethyl-	63597285	2.642
	3.0191	cyclobutanol	25082240	1.042
	14.5127	2-nonen-1-ol, (E)-	9778208	0.406
	10.4516	1-hexanol, 2-ethyl-	9186676	0.382
	13.8289	(S)-(+)-6-methyl-1-octanol	7995804	0.332
	10.6121	3,5-octadien-2-ol	7552012	0.314
	8.1148	z-4-dodecenol	5857625	0.243
	6.557	2-methylenecyclohexanol	5563936	0.231
	21.19	1-decanol, 2-hexyl-	4915378	0.204
	16.344	4,8-decadien-3-ol, 5,9-dimethyl-	4307269	0.179
	20.3992	phenol, 2,4,6-trimethyl-	3719596	0.155
	24.0024	acetyleugenol	3291815	0.137
	14.3759	1-pentanol, 2,4,4-trimethyl-	2738614	0.114
	18.2289	2-hexadecanol	2690780	0.112
	24.377	1-dodecanol, 2-hexyl-	2600219	0.108
	25.7922	benzenemethanol, 3,4-dimethoxy-	2160121	0.090
	21.5943	1,5,7-octatrien-3-ol, 2,6-dimethyl-	2000941	0.083
	24.5792	ethanol, 2-(octadecyloxy)-	1156916	0.048
	24.4781	1-octanol, 2-butyl-	1106286	0.046
	26.3095	epicedrol	833301	0.035
	28.6403	phenol, 4-(1-methyl-1-phenylethyl)-	647959	0.027
Aldehyde	1.7348	butanal, 3-methyl-	95674498	3.975

Group	RT (min)	Compound	Area	Propotion
	9.6191	octanal	48335129	2.008
	11.2483	2-octenal, (E)-	47543820	1.975
	9.8986	2,4-heptadienal, (E,E)-	47231155	1.962
	12.5862	nonanal	43285062	1.798
	18.6392	2,4-decadienal, (E,E)-	38527389	1.601
	14.2154	2-nonenal, (E)-	35521572	1.476
	6.8245	heptanal	25749471	1.070
	5.6889	2-hexenal, (E)-	13262208	0.551
	2.6386	pentanal	10773657	0.448
	8.3289	2-heptenal, (Z)-	9013727	0.374
	15.5116	decanal	8447849	0.351
	7.104	methional	4412927	0.183
	17.0159	2-decenal, (E)-	2779261	0.115
	13.6327	2-hexenal, 2-ethyl-	2662186	0.111
	30.4122	tetradecanal	2417150	0.100
	21.8857	2,6-dodecadien-1-al	1698224	0.071
	29.1754	heptanal	581046	0.024
	29.0863	octanal, 2-(phenylmethylene)-	530053	0.022
	32.4873	heptadecanal	219276	0.009
Ketone	17.9732	2-undecanone	63102715	2.622
	19.2754	1-(2-pyrazinyl)butanone	55467061	2.304
	12.3246	3,5-octadien-2-one, (E,E)-	31060982	1.290
	8.8699	cyclobutanone, 2,3,3-trimethyl-	19162738	0.796
	20.8451	bicyclo[3.2.1]oct-3-en-2-one, 4-methyl-	12880475	0.535
	22.1057	5,9-undecadien-2-one, 6,10-dimethyl-, (E)-	11194065	0.465

Group	RT (min)	Compound	Area	Propotion
	19.0613	pyrethrone	6609592	0.275
	27.7127	1-(4-benzylphenyl)-ethanone	5466848	0.227
	20.6549	1-methyl-2-decalone	5314061	0.221
	15.1905	2-decanone	5158337	0.214
	23.5446	2-piperidinone, n-[4-bromo-n-butyl]-	3091464	0.128
	18.437	1h-inden-1-one, 2,3-dihydro-2-methyl-	2794857	0.116
	22.4803	cyclohexanone, 2-ethyl-	2652364	0.110
	21.4932	tetrahydro[2,2']bifuranyl-5-one	2187468	0.091
	16.5997	2,3-octanedione	1887089	0.078
	27.243	β-iso-methyl ionone	1164169	0.048
	26.4938	benzophenone	819259	0.034
Organic	4.018	acetic acid	16523028	0.686
	17.5927	nonanoic acid	2586473	0.107
	24.9122	nonahexacontanoic acid	1744480	0.072
	26.1014	cyclooctaneacetic acid, 2-oxo-	1007635	0.042
Others	25.6376	diethyl phthalate	236990881	9.846
	11.6764	ethanone, 1-(1h-pyrrol-2-yl)-	90991137	3.780
	17.1051	quinoline, 1,2,3,4-tetrahydro-	34351693	1.427
	7.7224	1h-pyrrole, 1-ethyl-	33506346	1.392
	8.7689	dimethyl trisulfide	19898221	0.827
	3.5602	1h-pyrrole, 2-methyl-	16080608	0.668
	12.0094	pyrazine, 3-ethyl-2,5-dimethyl-	15723685	0.653
	10.8975	benzeneacetaldehyde	14794588	0.615
	9.2862	furan, 2-pentyl-	13756828	0.572
	8.4894	benzaldehyde	12010374	0.499

Group	RT (min)	Compound	Area	Propotion
	17.6759	benzenamine, n,n-diethyl-3-methyl-	11854707	0.493
	20.1911	benzimidazole, 2-amino-1-methyl-	11015999	0.458
	18.9067	2-oxo-1-methyl-3-isopropylpyrazine	10754120	0.447
	27.0527	1,1'-biphenyl, 2,2',5,5'-tetramethyl-	9372368	0.389
	3.7861	pyrrole	8910970	0.370
	21.7311	3,3'-bis(1,2,4-oxadiazolyl)-5,5'-diamine	8374419	0.348
	16.0883	furan, 3-phenyl-	7326636	0.304
	17.8781	dihydrocarveole	6690622	0.278
	14.9051	pyrazine, 2,3-dimethyl-5-(1-propenyl)-, (E)-	6499904	0.270
	10.291	pyrazinamide	6090532	0.253
	7.3002	pyrazine, 2,3-dimethyl-	4952740	0.206
	20.3219	11,11-dimethyl-spiro[2,9]dodeca-3,7-dien	4529642	0.188
	25.4889	3-methyl-4-phenyl-1h-pyrrole	4421370	0.184
	19.3824	2-acetylaniline	4218780	0.175
	16.7127	2-isoamyl-6-methylpyrazine	3790357	0.157
	19.4657	pyridine, 2-(1-methyl-2-pyrrolidinyl)-	3751353	0.156
	12.8835	1,2,4-triazolo[4,3-b]pyridazine, 8-methyl-	3649233	0.152
	25.9408	2-(5-aminohexyl)furan	3534760	0.147
	18.324	2-acetylaniline	3121021	0.130
	22.9262	1,3,5-triazine-2,4-diamine, 6-phenoxy-	2563838	0.107
	25.043	1,11-dodecadiyne	2192776	0.091
	26.6305	3-hydroxypyridine monoacetate	1758851	0.073
	30.5668	isopropyl myristate	777518	0.032
	30.2873	2-ethylhexyl salicylate	234038	0.010

Group	RT (min)	Compound	Area	Propotion
	31.53	1-butyl 2-isobutyl phthalate	208351	0.009
	31.1792	galoxolide	153315	0.006
		Total	2407041009	100

The volatile compounds detected consisted of various groups of compounds including hydrocarbons (50 species) which were the most compounds detected with pentadecane (14.639%) as the type of compound which had the largest proportion. Other groups of compounds detected were 20 types of aldehyde compounds with butanal, 3-methyl- (3.975%) and octanal (2.008%) having the largest proportion, 17 types of ketones with 2-decanone (2.622%) having the largest proportion, 23 types alcohols with 1-octen-3-ol (1.1981%) and 1-hexanol (2.794%) have the largest proportion. In addition to this group, a number of organic compounds and other volatile compounds were detected in a relatively high number such as diethyl phthalate (9.846%).

The results of the analysis of volatile compounds were successfully detected as many as 133 types of compounds for samples of mackerel fish stew water extracted at 80 ºC for 30 minutes. The composition of the volatile flavor compounds of boiled water of mackerel bones is presented in Table 2.

Table 2. The results of the analysis of volatile compounds of mackerel bone broth

Group	RT(min)	Compound	Area	Proportion
Hyidrocarbon	23.2589	pentadecane	242023736	18.545
	27.8671	heptadecane	58228378	4.462
	27.9979	heptadecane, 2,6-dimethyl-	41124104	3.151
	19.8578	tridecane, 2-methyl-	8455860	0.648
	12.247	cyclopentane, ethyl-	8367492	0.641
	14.5957	1-nonene	7114752	0.545
	22.6881	cyclopropane, nonyl-	6507482	0.499
	17.3427	1,4-octadiene	6389863	0.490
	18.0622	tridecane	5524550	0.423
	20.4643	cyclotetradecane	4775543	0.366

Group	RT(min)	Compound	Area	Proportion
	20.7141	tetradecane	4685105	0.359
	12.9367	cyclohexane, 1,2,3-trimethyl-	4654260	0.357
	22.7535	1,2-di-but-2-enyl-cyclohexane	4261971	0.327
	19.6141	tridecane, 4-methyl-	3525900	0.270
	15.2795	dodecane	2863411	0.219
	16.8076	2,6-octadiene-1,8-diol, 2,6-dimethyl-	2817773	0.216
	27.3736	cyclotetradecane	2674090	0.205
	14.9822	naphthalene	2334393	0.179
	19.9768	cis,cis- and cis,trans-1,9-dimethylspiro[4.5]decane	2301677	0.176
	13.1567	4-nonene	2185349	0.167
	16.4984	cyclotridecane	1942064	0.149
	21.4097	caryophyllene	1793400	0.137
	22.2838	undecane	1745781	0.134
	13.3946	2-hexene, 3-methyl-, (Z)-	1610096	0.123
	15.8086	cyclohexene, 1,2-dimethyl-	1605601	0.123
	12.7822	octane, 4-methyl-	1486117	0.114
	15.9751	cyclohexane, 1,2,4-trimethyl-	1475844	0.113
	23.5444	2-piperidinone, n-[4-bromo-n-butyl]-	1456716	0.112
	23.8654	3-hexene, 3,4-dimethyl-, (Z)-	1403988	0.108
	24.1925	hentriacontane	1345263	0.103
	24.7514	dodecane	1221469	0.094
	22.0043	cyclopentane, 1,1,3,3-tetramethyl-	1086242	0.083
	13.5135	cyclopropane, 1,1-diethyl-	1060174	0.081

Group	RT(min)	Compound	Area	Proportion
	28.2357	naphthalene, 1,2,3-trimethyl-4-propenyl-, (E)-	897546	0.069
	30.0076	nonadecane	861632	0.066
	17.5211	1-methyl-2-methylenecyclohexane	735203	0.056
	25.2033	cetene	680664	0.052
	27.4984	2,6-diisopropylnaphthalene	597187	0.046
	22.4027	allo-aromadendrene	528884	0.041
	23.6752	butylated hydroxytoluene	435349	0.033
	26.9038	cyclotetradecane	401160	0.031
	28.4379	2,6-diisopropylnaphthalene	396379	0.030
	27.6055	1,7-di-iso-propylnaphthalene	340782	0.026
	28.533	1,4-di-iso-propylnaphthalene	306265	0.023
	28.8898	octadecane	235664	0.018
	29.3833	trans-1,2-diphenylcyclobutane	198773	0.015
Alcohol	9.0421	1-octen-3-ol	46357835	3.552
	3.0605	cyclobutanol	25689230	1.968
	12.5859	nonanal	23767670	1.821
	6.1167	1-hexanol	17904747	1.372
	10.4513	1-hexanol, 2-ethyl-	11112941	0.852
	10.6119	3,5-octadien-2-ol	4367216	0.335
	8.0194	z-4-dodecenol	3901936	0.299
	6.5805	2-methylenecyclohexanol	2679510	0.205
	20.3276	phenol, 2,4,6-trimethyl-	2471023	0.189
	14.3757	1-pentanol, 2,4,4-trimethyl-	2321828	0.178

Group	RT(min)	Compound	Area	Proportion
	21.2016	1-decanol, 2-hexyl-	1814190	0.139
	25.7979	benzenemethanol, 3,4-dimethoxy-	1648443	0.126
	24.02	acetyleugenol	1060661	0.081
	18.2168	2-hexadecanol	1042681	0.080
	24.3827	1-dodecanol, 2-hexyl-	856827	0.066
	21.6	1,5,7-octatrien-3-ol, 2,6-dimethyl-	825032	0.063
	24.5849	ethanol, 2-(octadecyloxy)-	735605	0.056
	23.7465	2,4-di-tert-butylphenol	723083	0.055
	24.4779	1-octanol, 2-butyl-	641918	0.049
	26.3033	epicedrol	496232	0.038
	28.6341	phenol, 4-(1-methyl-1-phenylethyl)-	354956	0.027
Aldehyde	1.7464	butanal, 3-methyl-	68728721	5.266
	4.5648	hexanal	38067441	2.917
	9.6129	octanal	28045356	2.149
	6.8243	heptanal	18262536	1.399
	11.2481	2-octenal, (E)-	16428016	1.259
	14.2151	2-nonenal, (E)-	11378928	0.872
	17.1049	2-decenal, (E)-	10765549	0.825
	9.9043	2,4-heptadienal, (E,E)-	10242918	0.785
	5.6945	2-hexenal, (E)-	6940043	0.532
	2.6681	pentanal	6206373	0.476
	8.3346	2-heptenal, (Z)-	3967313	0.304
	15.5114	decanal	3762372	0.288

Group	RT(min)	Compound	Area	Proportion
	30.4774	tetradecanal	1514737	0.116
	13.6324	2-hexenal, 2-ethyl-	975488	0.075
	21.8854	2,6-dodecadien-1-al	691277	0.053
	18.5497	2,4-decadienal, (E,E)-	591940	0.045
	29.086	octanal, 2-(phenylmethylene)-	580843	0.045
	32.493	heptadecanal	200382	0.015
Ketone	17.967	2-undecanone	20182728	1.546
	12.3243	3,5-octadien-2-one, (E,E)-	12238226	0.938
	8.8756	cyclobutanone, 2,3,3-trimethyl-	12034660	0.922
	20.8508	bicyclo[3.2.1]oct-3-en-2-one, 4-methyl-	4436742	0.340
	27.7065	1-(4-benzylphenyl)ethanone	3446541	0.264
	22.1233	5,9-undecadien-2-one, 6,10-dimethyl-, (E)-	3388878	0.260
	19.0849	pyrethrone	1736951	0.133
	15.1903	2-decanone	1607710	0.123
	21.493	tetrahydro[2,2']bifuranyl-5-one	1113459	0.085
	27.2428	β-iso-methyl ionone	1021120	0.078
	16.6114	2,3-octanedione	786717	0.060
	26.4995	benzophenone	534471	0.041
Organic	4.0297	acetic acid	11807797	0.905
	24.9119	nonahexacontanoic acid	736534	0.056
	26.113	cyclooctaneacetic acid, 2-oxo-	331071	0.025
Others	25.6373	diethyl phthalate	219336156	16.806
	7.7637	1h-pyrrole, 1-ethyl-	37389887	2.865

Group	RT(min)	Compound	Area	Proportion
	11.7	ethanone, 1-(1h-pyrrol-2-yl)-	35008815	2.682
	19.2692	1-(2-pyrazinyl)butanone	16285029	1.248
	27.0525	1,1'-biphenyl, 2,2',5,5'-tetramethyl-	11364574	0.871
	8.7745	dimethyl trisulfide	8657749	0.663
	10.8973	benzeneacetaldehyde	8639776	0.662
	8.4892	benzaldehyde	8339174	0.639
	9.2859	furan, 2-pentyl-	7752710	0.594
	20.1908	benzimidazole, 2-amino-1-methyl-	7356657	0.564
	3.7918	pyrrole	6633952	0.508
	17.6816	benzenamine, n,n-diethyl-3-methyl-	4205944	0.322
	12.0092	pyrazine, 3-ethyl-2,5-dimethyl-	4122575	0.316
	7.294	pyrazine, 2,3-dimethyl-	3209867	0.246
	21.7368	3,3'-bis(1,2,4-oxadiazolyl)-5,5'-diamine	2469932	0.189
	16.0881	furan, 3-phenyl-	2465406	0.189
	3.5718	1h-pyrrole, 2-methyl-	2103288	0.161
	18.9124	2-oxo-1-methyl-3-isopropylpyrazine	1971952	0.151
	14.8989	pyrazine, 2,3-dimethyl-5-(1-propenyl)-, (E)-	1945272	0.149
	17.8719	dihydrocarveole	1895228	0.145
	25.4708	3-methyl-4-phenyl-1h-pyrrole	1646301	0.126
	22.92	1,3,5-triazine-2,4-diamine, 6-phenoxy-	1556838	0.119
	19.4654	pyridine, 2-(1-methyl-2-pyrrolidinyl)-	1541232	0.118
	10.1481	pyrazine, 2-ethenyl-6-methyl-	1519567	0.116
	25.9465	2-(5-aminohexyl)furan	1511469	0.116

Group	RT(min)	Compound	Area	Proportion
	18.3238	2-acetylaniline	1462263	0.112
	26.6303	3-hydroxypyridine monoacetate	1267920	0.097
	25.0427	1,11-dodecadiyne	993094	0.076
	16.7184	2-isoamyl-6-methylpyrazine	992699	0.076
	30.5665	isopropyl myristate	466182	0.036
	30.2871	2-ethylhexyl salicylate	317844	0.024
	31.5298	1-butyl 2-isobutyl phthalate	259653	0.020
	31.292	galoxolide	212651	0.016
		Total	1305092990	100

Volatile compounds detected consisted of various groups of compounds including hydrocarbons (46 species) which were the highest group of compounds detected with pentadecane (18.545%) as the type of compound which has the largest proportion. Other groups of compounds detected were 18 types of aldehydes with Butanal, 3-methyl- (5.266%), hexanal (2.917%) and octanal (2.149%) having the largest proportion, 12 types of ketones with 2-Undecanone (1.546%) has the largest proportion, 22 types of alcohol with 1-octen-3-ol (3.552%) have the largest proportion. In addition to these groups, a number of organic compounds and volatile compounds were detected in quite high amounts such as diethyl phthalate (16.806%).

3. 1. Hydrocarbon

Based on the results of the analysis of volatile compounds, pentadecane compounds are the compounds with the highest proportion in both samples. Pentadecane is the highest. The results of the analysis of volatile compounds in boiled fish head mackerel are pentadecane compounds 14,639%. Pentadecane compounds are also found in mackerel fish bone cooking water of 18.545% which is a group of hydrocarbons with the largest proportion in both samples. Pentadecane compounds are compounds that belong to a group of hydrocarbons known as alkanes. This hydrocarbon consists of hydrogen atoms and saturated carbon atoms (Irawan 2008). Pentadecane is considered a hydrocarbon lipid molecule. Pentadecane compounds are also known to be detected in fresh catfish, fresh carp, fresh and steamed Spanish mackerel. The alkane group can be derived from decarboxylation and separation of fatty acid carbon chains. Some cyclic hydrocarbons identified in fish are the result of secondary reactions from thermal oxidation (heating) carotenoids and other unsaturated fats. The heptane compound, tridecane, pentadecane was previously detected in the volatile component of the squid. Hydrocarbons are generally considered to have a smaller overall effect on food flavor due to the high fragrance threshold.

3. 2. Aldehyde

Aldehydes can provide a significant aroma, either pleasant or rancid, for food ingredients, and their odor threshold values are usually lower than alcohol. Thus, even the slightest amount of aldehyde can replace the scent effect of several other substances. 2,4-heptadienal- (E, E) compounds found in samples of mackerel head cooking water 1.962% and samples of mackerel boiled water 0.785% have a smell like cinnamon or like oil that is oxidized. The 2,4-heptadienal- (E, E) compound found in both samples was also detected in the flavor of meat aroma which has green, broth and fatty aroma characteristics. 2-nonenal compound, (E) - found in both samples was also detected in gray mullet fish and has been associated with rancid and bitter aroma in fish. In addition, in the samples of mackerel head cooking water there is compound 2-Octenal, (E) - with a proportion of 1.975% which has a cinnamon-like aroma which is also detected in fresh patin and fresh and steamed Spanish mackerel has the characteristic aroma like orange. While heptanal, octanal, or nonanal compounds may give a more distinctive fishy aroma.

3. 3. Alcohol

Alcohol compounds detected were as many as 23 compounds in samples of boiled fish head mackerel and 22 compounds in samples of mackerel fish bone cooking water. The highest proportion of compounds from the two samples is 1-octen-3-ol compound with the number of each proportion of 3.774% and 3.552%. Although alcohol has a relatively high odor threshold value, unsaturated alcohols such as 1-octen-3-ol, with a normally lower threshold value, are expected to have a higher impact on the overall aroma and 1-octen-3-ol has description of the smell of mushrooms. Volatile alcohols detected in samples have a small impact on food aroma due to high odor thresholds, unless they are not saturated or are at high concentrations. 1-octen-3-ol compounds, with normally lower threshold values, are expected to have a higher impact on overall aroma.

In addition to the 1-octen-3-ol compound detected in both samples there were also other alcohol compounds which were also found in the two samples namely 1-hexanol with the proportion of 2.794% and 1.372%, respectively. 1-hexanol compound also known to be detected in fresh and cooked silver carp, wild sea bream and aquaculture, fresh black bream, mackerel and catfish.

3. 4. Ketone

Ketones, together with aldehydes, are the main products of lipid autooksidation from fatty acids or auto-oxidation of unsaturated fatty acids through hydroperoxide. Ketones originate from enzymatic degradation of poly-unsaturated fatty acids, amino acids or microbial oxidation. The compounds 2,3-octanedione and 3,5-octadien-2-one found in both samples were also detected in squid, which is a strong aroma of squid and the latter has been reported as a product of lipid oxidation in seafood. The ketone compound 2,3-octanedione detected in the two previous samples was detected in fresh sardines.

Compound 2-Undecanone is a ketone also known as methyl nonyl ketone. 2-Undecanone compounds are found in cloves. 2-Undecanone is found in palm kernel oil and soybean oil. 2-

Undecanone is an important constituent of rue oil and is found in many other essential oils. Compound 2-Undecanone is also found in black currant buds, raspberries, black berries, peaches and other fruits. Some ketones may contribute to the smell of cheese fish sauce. Generally, the ketone group present in the sample is known to contribute to the sweet aroma of many crustaceans.

3. 5. Organic and others

In addition to compounds from the hydrocarbon group, aldehydes, alcohols and ketones, there are also several organic compounds identified in both samples. The highest organic compound is acetic acid or acetic acid. Acetic acid compounds identified in the two previous samples were also identified in fish sauce with an aroma like vinegar.

Diethyl phthalate compounds are generally organic compounds because they consist of carbon, hydrogen and oxygen atoms. The compound diethyl phthalate is a clear and colorless liquid with no significant odor. Used in making perfumes, plastics, mosquito repellents and many other products. When compared with volatile flavor compounds that are commonly found in fish, these compounds have a considerable proportion. Therefore, it can be said that the fish sampled are fish that live in aquatic habitats that have been polluted by this compound.

3. 6. Proximate

The proximate test results of boiled water of mackerel heads and mackerel bones can be seen in **Table 3**. Broadly speaking, the results of the proximate analysis between boiled water of mackerel heads and mackerel bones are not much different when viewed from water, ash, fat and protein levels.

Table 3. Proximate analysis results

Parameter	Air Rebusan Kepala Tenggiri (%)	Air Rebusan Tulang Tenggiri (%)
Kadar Air	96,08	96,69
Kadar Abu	1,15	1,54
Kadar Lemak	0,28	0,44
Kadar Protein	2,78	1,84

4. CONCLUSIONS

Water content is the amount of water contained in the material expressed in percent. Water content is also one of the most important characteristics of food, because water can affect appearance, texture, and taste in food. Water content in food ingredients also determines the freshness and durability of the food, high water content results in easy bacteria, molds, and yeast to multiply, so that changes will occur in food ingredients. This high water content is caused by the two samples being tested in liquid form.

The ash content of a food indicates the presence of inorganic minerals in these foods. Determination of ash content is closely related to the mineral content contained in a material, the purity and success of a material produced. The ash content is caused by boiling temperature which causes the water content to decrease so that more residue is left in the material.

Fat is one of the main ingredients in food. Fat sources of energy and contains essential fats. The fat component plays an important role that determines the physical characteristics of food such as aroma, texture, taste, and appearance, if fat is removed then one physical characteristic becomes lost. The boiling process can reduce fat levels due to the nature of fat which cannot stand the heat, during the process of cooking melting fat and even evaporates (volatile) into other components such as flavor.

Proteins commonly found in broth are globular / spheroprotein proteins. This protein is spherical, mostly found in food ingredients such as milk, eggs, and meat. These proteins dissolve in saline and dilute acids, also change more easily under the influence of temperature, salt concentration, acid solvents, and bases when compared to fibrillary proteins. This protein is easily dehydrated, its molecular structure changes which is followed by changes in its physical and physiological properties as experienced by enzymes and hormones. The boiling process can reduce protein levels in food, because processing using high temperatures will cause protein denaturation resulting in coagulation and decreased solubility or solubility. Warming up of proteins can cause both expected and unexpected reactions. These reactions include denaturation, loss of enzyme activity, changes in solubility and hydration, discoloration, derivatization of amino acid residues, breaking of peptide bonds, and formation of compounds that are sensory active. The reactions that occur when heating these proteins can damage the condition of the protein, so that protein levels can decrease

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