J. Fish. Sci. Tech. 4(4), 246~251, 2001

JOURNAL OF
FISHERIES SCIENCE
AND TECHNOLOGY

Quality Properties of Seasoned-Dried Pacific Saury Treated with Liquid Smoke during Storage

3. Changes in Fatty Acid and Taste Compounds of Seasoned-Dried Pacific Saury Treated with Liquid Smoke During Storage

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(Received September 2001, Accepted December 2001)

As a series of studies on improving quality of seasoned-dried Pacific saury, fatty acid compositions and taste compounds of the seasoned-dried saury treated with liquid smoke (T2 product) were examined during storage, comparing with control (C, seasoning only). In the both samples, the major fatty acids were 22:6n-3, 16:0, 22:1n-11, 20:1n-11, 18:1n-9, 14:0, 20:5 n-3 and 16:1n-7. The contents of saturated fatty acids in C and T2 increased with increasing storage period, while those of polyunsaturated fatty acids decreased. After drying, the contents of 7 non-volatile organic acids contents detected in this study decreased, and the others of non-volatile organic acids, except for malic and citric acids, in both C and T2 decreased with storage period. The contents of nucleotides and their related compounds in both C and T2 decreased with increasing storage period. The content of total free amino acids in raw sample was 556.96 mg/100 g and increased up to 895.77 mg/100 g and 958.40 mg/100 g in C and T2, respectively, after drying, and total contents of free amino acids in both C and T2 somewhat decreased after 60 days of storage.

Key words: Seasoned-dried Pacific saury, Liquid smoke, Taste compounds, Fatty acid compositions

Introduction

A long with the beginning of civilization in the west, smoking and liquid techniques have been used in most of their lifes as a means of preservation and flavoring (Sink, 1979), and numerous studies have been conducted for its antioxidative and antimicrobial effects. Additionally, unique flavor and taste of smoked products have rapidly been more popular, and several studies about application of liquid smoke were attempted to enhancer quality stability of dried shellfishes such as filefish (Lee et al., 1982), baby clam (Lee et al., 1984a), sea mussel (Lee et al., 1983b) and oyster (Lee et al., 1983a) after treating with liquid smoke.

However, among dark fleshed fishes, there have not been researched about storage stability of Pacific saury with liquid smoke. For the research with Pacific saury, there were only a few studies about changes of TMA and DMA contents (Park et al., 1981a) after hot-air drying and changes of histamine contents (Park et al., 1981b) in Pacific saury.

Therefore, if a simple and modified technique using liquid smoke should be applied to Pacific saury successfully, it could be beneficial to fishery processing field.

The objective of this study is to examine fatty acid and taste compounds of seasoned-dried Pacific saury treated with liquid smoke during storage, as a series of studies on improving quality of seasoned-dried Pacific saury.

Materials and Methods

Materials

Pacific saury (*Cololabis saira* 28±cm length, 93±

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6 g weight) and liquid smoke (Scansmoke PB 2110) were treated with same methods described in previous paper (Cha et al., 2001) for processing of smoked and seasoned-dried products.

Processing of seasoned-dried Pacific saury

Two types of seasoned-dried Pacific saury including control (C, treatment of seasoning only) and T2 (treatment with 5% liquid smoke after seasoning) were produced. More details of processing procedure have been described in previous paper (Cha et al., 2001). Two products completely processed were packaged with 300 g each unit in a polypropylene film (0.08 mm thickness) and stored at ambient temperature (19±5℃) during 80 days.

Analysis of fatty acid compositions

Total lipid extraction was followed by Bligh and Dyer method (1959), and then fatty acid composition was determined by a method of Suzuki et al. (1985) using 200 mg of oil extracted. GC (HP 6890, Hewlett-Packard Co., USA) (splitless mode; helium carrier gas at 2.5 mL/min), equipped with a HP-INNOWax™ capillary column (30 m length×0.32 mm i.d.×0.5 μm film thickness) was used for analysis of the fatty acids. Oven temperature was programmed at 180℃ initially (10 min hold), increased to 230℃ at 3℃/min (15 min hold). Injection port and detector (FID) temperatures were set at 250℃, respectively. Quantification of each fatty acid regarded a united peak of retention time in chromatogram of sample was appeared as area percent to total area percent.

Analysis of non-volatile organic acids

Non-volatile organic acids were analyzed by a modified method of Lee et al. (1993). Ten g of sample were put into a mortar with 50 mL of ethanol, homogenized for 2 min and filtered (Whatman No. 2). The filtered solution were taken up, and 10 mL of 80% ethanol were added to the residue. It was homogenized for 2 min and had filtration, and these procedure were conducted 3 times more. Each of the filtered solution was gathered and made to 100 mL with distilled water. Fifty mL taken were dehydrated to about 2 mL on a vacuum rotary evaporator (Eyela, N-INW, Tokyo Rikakikai Co., Ltd, Japan) and completely dried in vacuum desiccator. Methylation was led using 14% BF_3/ethanol solution (Sigma Chemical Co., USA) for 30 min at 80℃. After standing for 10 min at ambient temperature, the sample were transferred by using 4 mL of 70% saturated ammonium sulfate and 5 mL of chloroform to a separating funnel. It was shaken for 1 min and stood for 5 min in order to shift methyl ester of organic acid to chloroform layer. After that, the chloroform layer were taken up and dehydrated by Na_2SO_4, and 1 mL of chloroform including methyl laurate (Sigma Chemical Co., USA) as a internal standard was added to dehydrated chloroform. The solution was concentrated to 1 mL by N_2 gas and used for analysis of GC. GC (HP 6890, Hewlett-Packard Co., USA) (splitless mode; helium carrier gas at 1.2 mL/min constant flow) was equipped with a HP-INNOWax™ capillary column (30 m length×0.32 mm i.d.×0.5 μm film thickness). Oven temperature was programmed at 50℃ initially (1 min hold), increased to 230℃ at 10℃/min (8 min hold). Injection port and detector (FID) temperatures were set at 200 and 250℃, respectively. Duplicate analyses were performed on each extract.

Identification and quantification of non-volatile organic acids regarded a united peak of retention time in chromatogram of sample and standard organic acids (Sigma Chemical Co., USA) injected at the same conditions, and the quantitative analysis of organic acids was followed by Cho (1983).

Analysis of nucleotides and their related compounds

Nucleotides and their related compounds were determined by the method of Lee et al. (1984b). The analysis of HPLC were followed by conditions: HPLC column, HP ZOBAX™ column (XDB-C18, Hewlett Packard, USA); mobile phase, 1% triethylamine phosphoric acid buffer solution (pH 6.5); flow rate, 1 mL/min. Positively identified compounds were determined using comparison of retention time for each compound relative to the standard compound and quantified by peak area using standard calibration curve.

Analysis of free amino acids

Free amino acids were determined according to a modified method of Lee et al. (1981), and the free amino acids was quantitatively analyzed using ami-

no acid analyzer (Biochrom20, Pharmacia Biotech, USA).

Results and Discussion

Changes of fatty acid compositions during storage

The compositions of total fatty acids of seasoned-dried Pacific saury during storage are shown in Table 1. In the both samples, the major fatty acids were 22:6n-3, 16:0, 22:1n-11, 20:1n-11, 18:1n-9, 14:0, 20:5n-3 and 16:1n-7. Lee et al. (1986b) and Jeong et al. (1998) reported that the main fatty acids in lipid of sardine were 16:0, 16:1, 18:1, 20:5 and 22:6, and the contents of polyunsaturated fatty acids (PUFA) including 20:5 and 22:6 in sardine were higher than those of other fishes, which is similar to the main fatty acids in Pacific saury in this study. The content of monounsaturated fatty acids (MUFA) (36.1~41.1% range) were the highest in the total fatty acids of both C and T2 seasoned-dried products, and PUFA (31.7~33.6% range) and saturates (17.3~26.1% range) were followed in order. In the saturated fatty acids (SFA), the content of 14:0 (4.4~6.2% range) and 16:0 (8.8~14.6% range) were higher than those of the others, and the contents of SFA in both C and T2 increased after 60 days of storage. In the MUFA, the content of 22:1n-11 (7.4~13.2% range) was the highest, and 20:1n-11 (4.8~8.8% range) and 18:1n-9 (3.6~6.8% range) were followed in order, and the content of MUFA in C somewhat decreased after 60 days of storage, while that in T2 increased but not much. In the PUFA, the contents of 22:6n-3 (10.9~15.7% range) and 20:5n-3 (4.1~4.7% range) were higher, and the contents of PUFA (particularly 22:6 n-3) in both C and T2 decreased with increasing storage period but not significantly. As mentioned above, whereas increase in SFA, decrease trend in PUFA during storage is considered due to its unstable double bonds. According to Suh and Lee (1994), the contents of SFA and MUFA in dried conger eel increased with increasing storage period, while that of PUFA decreased. The report of Lee et al. (1989) about effects of antioxidant agents in dried anchovy was also similar to these results. According to Lee et al. (1986b), also, the compositions of SFA and MUFA in winter decreased because of decrease of triglyceride, which has accumulated in sardine muscles, whereas they increased by increase of accumulated lipid in summer. Lee et al. (1986a) reported that the contents of 20:5 and 22:6

Table 1. Change of fatty acid compositions of seasoned-dried Pacific saury during storage (area %)

Fatty acids	C[1]		T2	
	15 days	60 days	15 days	60 days
14:0	5.3	6.2	4.4	4.6
15:0 iso	0.2	0.3	0.2	0.3
15:0	0.6	0.7	0.3	0.6
16:0 iso	0.1	0.1	0.1	0.1
16:0	14.2	14.6	8.8	13.3
17:0 iso	0.6	0.1	0.7	0.4
17:0	0.5	0.5	0.3	0.4
18:0	3.3	3.0	1.7	2.5
20:0	0.1	0.3	0.2	0.3
22:0	0.3	0.3	0.4	0.5
Saturates	25.2	26.1	17.3	23.1
14:1n-7	1.6	0.3	1.8	0.5
15:1n-8	0.1	0.1	0.1	0.1
16:1n-9	2.2	1.8	2.0	3.4
16:1n-7	4.2	0.7	3.5	1.5
16:1n-5	0.2	0.3	0.2	0.3
17:1n-10	0.5	0.3	0.4	0.5
17:1n-8	0.2	0.1	0.2	0.1
18:1n-9	5.2	6.8	3.6	5.8
18:1n-7	1.6	2.2	0.9	2.3
18:1n-5	1.0	0.3	0.7	0.4
20:1n-11	7.3	8.8	6.7	4.8
20:1n-9	1.6	1.6	1.6	1.1
20:1n-7	0.5	0.4	0.4	0.6
22:1n-11	10.1	13.2	10.0	7.4
22:1n-9	0.5	0.9	0.5	0.8
22:1n-7	0.1	0.4	0.4	0.6
24:1n-7	4.3	1.1	2.9	2.6
Monoenes	41.1	39.2	36.1	37.3
18:2n-9	1.6	0.4	1.5	0.8
18:2n-6	1.7	2.6	1.1	1.6
18:3n-4	0.7	0.4	0.5	0.5
18:3n-3	1.5	1.5	1.6	1.5
18:4n-3	3.8	2.6	4.3	3.0
20:2n-6	0.5	0.8	1.3	0.5
20:3n-3	0.2	0.3	0.9	0.5
20:4n-6	0.8	1.2	2.2	1.5
20:4n-3	0.9	0.8	1.4	1.1
20:5n-3	4.4	4.7	4.1	4.4
21:5n-3	0.2	1.1	0.5	1.5
22:5n-6	0.3	0.5	0.3	1.4
22:5n-3	1.4	3.1	0.9	2.5
22:6n-3	15.7	13.2	13.0	10.9
Polyenes	33.6	33.2	33.5	31.7

[1] C; control (seasoning only), T2; treatment of liquid smoke after seasoning, refer to Cha et al. (2001).

were kept high levels although dried-anchovy was produced through the processing of boiling and drying. Furthermore, Lee et al. (1987) reported that in the dried filefish and smelt products, the compositions of 16:0 and 18:1 were high in SFA and MUFA, while those of 18:2, 20:5 and 22:6 were high in PUFA.

Changes of non-volatile organic acids during storage

The contents of non-volatile organic acids during storage are shown in Table 2. In raw and seasoned-dried products, total 7 non-volatile organic acids were detected. In the raw sample, the content of citric acid (13,646.22 mg/100 g) was highest and occurred 82.5% of total non-volatile organic acids detected, and lactic acid (1,681.93 mg/100 g), which is known as a main compound having the highest content in dark fleshed fishes, and malic acid (1,145.16 mg/100 g) were followed in order. After drying, most of non-volatile organic acid contents in raw decreased. Ryu and Lee (1978) reported that the contents of succinic acid, malic acid and lactic acid in raw decreased up to 40% of total contents of non-volatile organic acids during boiling and drying processing of sea mussel. In the changes of non-volatile organic acid contents in seasoned-dried products (C and T2) during storage, the contents of most of non-volatile organic acids, except for malic acid and citric acid, in both C and T2 decreased with increasing storage period. Especially, decrease of lactic acid was significant, and this is thought that lactic acid, which have been accumulated in fish meat, is degraded and converted into various short chain acids during drying processing and storage (Park et al., 1994). With increasing storage period, the contents of citric acid and malic acid increased. This is considered that free amino acids are generated and degraded from protein of fish meats by enzymatic action, and then organic acids generated by deamination of these free amino acids (Park et al., 1994), but further study should be needed to be carried out in this part. On the other hand, succinic acid known as a substance associated with TCA cycle and also a main organic acid of shellfishes (Park et al., 1994) was detected in low amounts.

Changes of Nucleotides and their related compounds during storage

The contents of nucleotides and their related compounds in seasoned-dried Pacific saury during storage are shown in Table 3. The content of hypoxanthine (34.55 mg/100 g) in raw sample was highest, and IMP and inosine were followed in order. This is considered that hypoxanthine is accumulated through the course of typical ATP degradation (Park et al., 1994), and the content of IMP was relatively higher than those of the other compounds in raw sample by AMP deaminase activity (Lee et al., 1981). On the other hand, after seasoning and drying, ATP was not detected in both C and T2, and the content of ADP in products increased. The contents of AMP, inosine and hypoxanthine somewhat decreased after processing, but that of IMP decreased seriously, which might be thought by action of 5'-nucleotide phosphatase (Lee and Han, 1972). Lee (1968) reported that during

Table 2. Changes of non-volatile organic acids in raw and seasoned-dried Pacific saury during storage[1)]

(mg/100 g, dry basis)

	Raw material	C[2)]		T2	
		15 days	60 days	15 days	60 days
Lactic	1,681.93 ± 157.00	208.00 ± 31.10	166.00 ± 2.24	309.18 ± 14.13	120.69 ± 1.39
Oxalic	29.92 ± 7.60	2.69 ± 0.22	1.17 ± 0.00	4.25 ± 0.26	N/D
Malonic	2.51 ± 0.10	0.71 ± 0.07	N/D	0.36 ± 0.12	N/D
Fumaric	5.20 ± 0.88	N/D[3)]	N/D	0.71 ± 0.02	N/D
Succinic	31.44 ± 1.31	3.39 ± 0.38	2.76 ± 0.04	4.35 ± 0.13	3.16 ± 0.49
Malic	1,145.16 ± 36.70	1,117.97 ± 42.84	1,543.08 ± 6.83	1,064.98 ± 1.86	1,599.18 ± 2.31
Citric	13,646.22 ± 80.30	9,957.36 ± 546.64	12,312.96 ± 201.47	11,753.95 ± 205.07	18,999.19 ± 418.58
Total	16,542.38	11,290.12	14,025.97	13,137.78	20,722.22

[1)] Mean value ± S.D. (n=3).
[2)] Refer to comment in Table 1.
[3)] Not detected.

Table 3. Changes of contents of nucleotides and their related compounds in raw and seasoned-dried Pacific saury during storage[1] (mg/100 g, dry basis)

	Raw material	C[2]		T2	
		0 day	60 days	0 day	60 days
ATP	0.81 ± 0.03	N/D[3]	N/D	N/D	N/D
ADP	2.30 ± 0.02	2.50 ± 0.04	0.16 ± 0.01	2.33 ± 0.02	0.05 ± 0.00
AMP	3.89 ± 0.04	1.37 ± 0.06	0.38 ± 0.00	1.87 ± 0.16	0.30 ± 0.00
IMP	30.69 ± 0.30	2.03 ± 0.02	0.21 ± 0.01	5.17 ± 0.08	0.30 ± 0.00
Inosine	14.50 ± 0.15	10.26 ± 0.03	0.97 ± 0.00	12.54 ± 0.02	0.84 ± 0.00
Hypoxanthine	34.55 ± 0.37	25.75 ± 0.06	7.47 ± 0.05	20.25 ± 0.03	7.53 ± 0.01
Total	86.74	41.91	9.19	42.16	9.02

[1] Mean value ± S.D. (n=3).
[2] Refer to comment in Table 1.
[3] Not detected.

hot-air drying the decrease rate of IMP is suddenly faster than those of other drying methods. In the changes of nucleotides and their related compounds contents during storage, the contents of nucleotides and their related compounds in both C and T2 decreased with increasing storage period due to continuous degradation courses, and sensory quality of seasoned-dried products could be affected by decrease trends of these taste compounds during storage. However, the contents of differences between C and T2 were not significant during storage.

Changes of Free amino acids during storage

The changes of contents of free amino acids in seasoned-dried Pacific saury during storage are shown in Table 4. The content of total free amino acids in raw sample was 556.96 mg/100 g, and after drying, increased up to 895.77 mg/100 g and 958.40 mg/100 g in C and T2, respectively. In the free amino acids in raw, the content of taurine was the highest, and alanine, glutamic acid, leucine, valine and arginine were followed in order. After seasoning and drying, the content of glutamic acid (44.64 mg/100 g) extremely increased to 459.83~474.20 mg/100 g which occupied 42.0~51.7% of total free amino acids in dried products. These trend was thought due to the effect of MSG added to fish meat during seasoning. Lee (1968) reported that these increase of amino acids after drying might be degree of strength of autolysis. In the changes of free amino acids in C and T2 during storage, total contents of them in both C and T2 somewhat decreased with increasing storage period, but not significantly. These decrease trends of free amino acids during storage are considered that they were degraded to amines, ammonia through decarboxylation and deamination by enzyme actions of microorganism (Park et al., 1994).

Table 4. Changes of contents of free amino acids in raw and seasoned-dried Pacific saury during storage (mg/100 g, dry basis)

Amino acids	Raw material	C[1]		T2	
		0 day	60 days	0 day	60 days
Taurine	175.18	85.46	59.32	111.25	96.76
Urea	8.56	6.33	0.00	3.87	0.00
Aspartic acid	10.30	5.52	8.08	5.63	8.54
Threonine	23.78	21.12	26.45	23.86	31.27
Serine	21.91	23.18	30.36	26.73	32.85
Glutamic acid	44.64	474.20	385.73	459.83	304.27
α-Aminoadipic acid	1.28	1.28	1.39	0.84	2.55
Proline	22.07	10.59	16.74	12.43	13.73
Glycine	21.59	20.04	27.91	22.66	31.67
Alanine	47.18	52.23	68.50	67.87	80.52
α-Aminoisobutyric acid	1.27	0.94	2.27	1.34	1.41
Valine	27.11	24.64	31.78	28.67	34.84
Cystine	2.33	1.17	4.94	2.03	3.97
Methionine	16.54	15.55	14.40	18.83	17.25
Cystathionine	0.78	1.63	2.98	2.02	7.03
Isoleucine	16.62	15.35	17.11	17.75	17.94
Leucine	29.89	37.82	39.30	43.10	38.93
Tyrosine	18.01	17.56	15.61	19.69	19.89
β-Alanine	3.76	1.52	18.54	2.43	48.82
Phenylalanine	19.62	18.52	18.37	20.96	18.33
β-Aminobutyric acid	6.98	4.34	6.79	5.37	5.73
Homocystine	4.01	3.93	0.00	5.41	6.42
γ-Amino-n-butyric acid	0.82	2.26	7.03	1.95	4.31
Ethanolamine	2.74	5.77	6.14	2.98	10.66
Hydroxylysine	3.42	3.46	0.84	2.22	6.34
Anserine	0.85	3.37	3.54	4.85	6.50
Carnosine	0.60	0.96	0.96	6.33	0.98
Arginine	25.13	37.05	44.22	37.51	47.01
Phosphoserine	0.00	0.00	2.91	0.00	5.17
Sarcosine	0.00	0.00	6.40	0.00	0.00
Total	556.96	895.77	868.61	958.40	903.66

[1] Refer to comment in Table 1.

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