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

2. Processing Conditions for Seasoned-Dried Pacific Saury Treated with Liquid Smoke

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Optimal conditions for processing of seasoned-dried Pacific saury treated with liquid smoke (T2) were evaluated by physicochemical and microbial experiments and sensory evaluation, comparing with control (seasoning only, C) and treatment I (0.05% Rosemary instead of liquid smoke, T1). Two hrs of seasoning time was set, and 23 hrs of drying time was determined in all samples. Finally, T2 product was made by soaking treatments (three times of 1 sec, 8 sec and 1 sec) in 5% (v/v) liquid smoke (Scansmoke PB 2110) after 30 min, 4 hrs and 22 hrs of hot-air drying, respectively. The histamine contents in 3 seasoned-dried products were in a 15.33~26.99 mg/100 g range. The water activities of 3 seasoned-dried products were 0.719~0.735 range, and the pH of T2 was lower than the others. In the comparison of POV and TBA values among products, the TBA values and POV of T1 and T2 were significantly low compared to C, and also the viable cell counts of T2 was relatively lower than those of the others. In the color values, significant changes were not found among products, and in the sensory evaluation for odor, taste and overall acceptance, T2 had relatively higher preference on the whole items.

Key words: Seasoned-dried sea food, Liquid smoke, Processing conditions, Pacific saury

Introduction

Numerous processing products have been developed in field of seafood products. However, fish and shellfish which use for processing of seafood products are known not only to have so many functional substances but also to have problems of their stability.

Especially, dark fleshed fish such as Pacific saury, mackerel, horse mackerel and gizzard shad have abundant polyunsaturated fatty acid (PUFA) including ω-3 compounds, but they are readily oxidized and hard to use for processing as raw materials due to their high lipid contents and unstable fish protein (Lee et al., 1982b; Lee et al., 1993).

In general, it is well known that lean fish is suitable for processing products. However, if products are processed with raw fish containing high lipid content, the products might be difficult to dry due to fat layer under the fish skin and cause off-flavor by lipid oxidation during storage (Park et al., 1994). Therefore, some of them have only been processed to salted-dried or canned foods with limited processing methods, and most of them have been used as raw fish on the markets (Lee et al., 1982b).

Among dark fleshed fish, especially, Pacific saury has not well been used for processing because of its properties of weak tissue. For the researches 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 compared to other dark fleshed fish such as sardine, mackerel.

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If a simple and modified technique such as liquid smoking method for Pacific saury processing is applied successfully, it could give a lot of advantages on the field of fishery processing. In the aspects of effective utilization of dark fleshed fish, therefore, we have attempted to process seasoned-dried Pacific saury with commercial liquid smoke which was proved to be safe without polycyclic aromatic hydrocarbons (PAHs) (Park et al., 2001).

The objectives of this study are to determine optimal processing conditions of seasoned-dried Pacific saury treated with liquid smoke.

Materials and Methods

Materials

Pacific saury, *Cololabis saira*, (28 ± 2 cm in length, 93 ± 6 g in weight) which had caught in the Korean East sea and frozen, were purchased from Myungbo Fisheries Inc. (Changwon, Korea). They were transferred to Food Processing Lab., Dept. of Food & Nutrition, Changwon National University (CNU), within 2 hrs for processing seasoned dried products.

Recipe of seasoning for processing of seasoned-dried Pacific saury is shown in Table 1. This is referred from commercial recipes using in a seasoning seafood factory in this district. The liquid smoke used for seasoned-dried products was selected by the results of analyzing their volatile flavor compounds in previous paper (Park et al., 2001). Among all commercial liquid smokes, Scansmoke PB 2110 (P. Broste A/S, Denmark) has relatively higher contents of acids and phenols than the other products. Therefore, scansmoke PB 2110 was used in this study.

Processing of seasoned-dried Pacific saury

The processing of seasoned-dried Pacific saury are shown in Fig. 1. First, frozen fish were dipped in water to thaw out, and followed by filleting. The fillets were washed under tap water for 30 min, drained for 20 min and divided into three portions as shown in Fig. 1. The control (C) was blended with seasoning only (Table 1) and stood for 2 hrs at 5℃ prepared before. These seasoned fillets (C) were set on trays and dried in hot-air dryer (Dongyang Scientific. Co. Ltd, Korea) for 23 hrs at 40℃

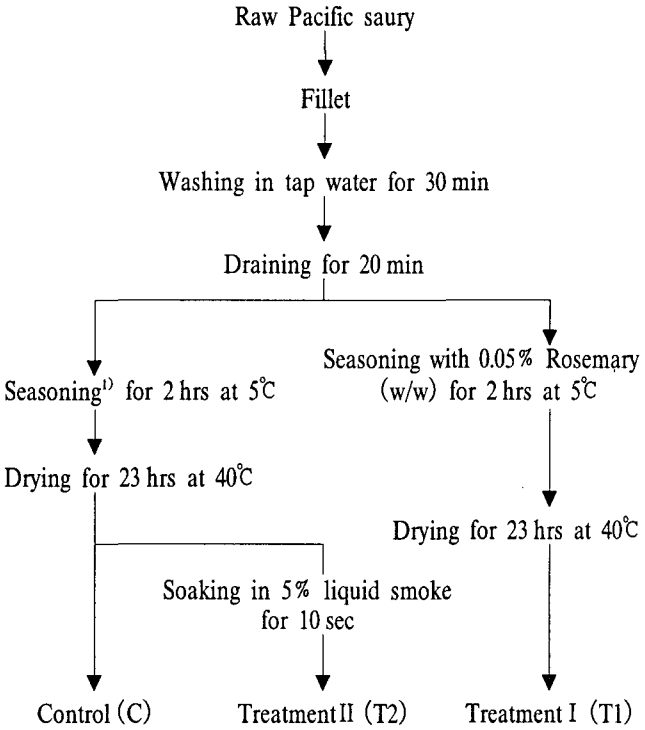

Fig. 1. Flow sheet of processing conditions for seasoned-dried Pacific saury.
[1] Seasoning recipes refer to comment in Table 1.

Table 1. Recipe of seasoning for preparation of seasoned-dried Pacific Saury

	Ratio to fish (% w/w)	Percent to total content (%)
Fillet		84.75
Sugar	12.21	10.35
Salt[1]	1.74	1.47
MSG	1.03	0.87
Sorbitol[2]	3.02	2.56
Total		100.00

[1] Saean Trading Co., Korea.
[2] Sorbitol 100, Samyang Genex Co., Ltd., Korea.

under the air velocity of 1.4 m/sec, 69% of humidity. Treatment II (T2) was soaked for 1 sec, 8 sec and 1 sec in 5% (v/v) liquid smoke (Scansmoke PB 2110, Denmark) after 30 min, 4 hrs and 22 hrs drying, respectively. Treatment I (T1) was treated with seasoning and 0.05% rosemary (w/w, SKW Trostberg Co., USA) before drying. During drying, each of fillet was turned over every 2 hrs and the trays were changed up and down in order to make equal drying. Here the optimal times of seasoning, drying

and soaking in 5% liquid smoke were obtained from experimented. Three products completely processed were used as final seasoned-dried ones.

Analysis of proximate composition

The contents of moisture, total sugar (Bertrand method), crude protein (semi-micro Kjeldhl method), crude lipid (Soxhlet method) and crude ash were determined by A.O.A.C. method (1990). Salt content was determined by salinity analyzer (TM-30D, Takemura Electric Works LTD., Japan).

Analysis of histamine contents

Histamine contents was followed by a method of KSFSN (2000). Namely, 10 g of raw sample homogenized were taken into a mortar, blended for 5 min with 20 mL of distilled water and 20 mL of 10% TCA. The blended solution was filtrated and then diluted to 50 mL with distilled water. The pH of diluted solution was adjusted to 4.6 with 10% NaOH and mixed with 10 mL of 0.4 N acetic acid buffer solution. The mixed solution was applied into Amberlite CG-50 resin column (100~200 mesh, ϕ 8 mm×55 mm) and then 80 mL of 0.2 N acetic acid buffer solution were applied into the column. Histamine absorbed to resin was drained out from the column by using 8 mL of 0.2 N HCl. The pH of the solution drained was adjusted to pH 7 with 1.5 N Na_2CO_3 and diluted to 10 mL with distilled water. Five mL of 1.1 N Na_2CO_3 and 2 mL of diazo solution were in order added into a test tube. After 1 min, 2 mL of the solution drained were put into the test tube, and it was strongly shaken. Absorbance of the solution in the test tube after 5 min was measured in a spectrophotometer (Varian 634S, Australia) at 510 nm comparing with the blank which was prepared with 2 mL of distilled water instead of 2 mL of the solution drained and calculated histamine content (mg/100 g) by standard curve.

Analysis of water activity (Aw), pH, volatile basic nitrogen (VBN), viable cell count and color value

Aw was determined using Digital Water Activity analyzer (Novasina, CH-8808, Pfaffikon, Swiss). The pH was determined, namely 5 g of sample were homogenized in a mortar with 50 mL of distilled water for 10 min and measured using pH meter (pH/ion meter DP-880, Dongwoo Medical System, Korea).

The contents of VBN was determined by Conway micro-diffusion method (Ministry of Social Welfare of Japan, 1960), and viable cell count was determined by the standard plate count method (Collins and Lyne, 1985). The sample for measuring color value, such as L-, a-, b-, and ΔE-value, were cut into a size($3\times3\times0.4$ cm^3) and determined using color difference meter (Minolta, CM-3500d, Japan).

Analysis of thiobarbituric acid (TBA) and peroxide value (POV)

Oil extraction for POV (meq/kg) was followed by the method of Bligh and Dyer (1959). After that, A. O.C.S method (1990) was followed.

TBA (mg/kg) was analyzed by steam distillation method (Tarladgis et al., 1960). TBA value was quantitatively expressed by thiobarbituric acid reactive substances (TBARS).

Sensory evaluation

Sensory evaluation was performed by 9 sensory panels chosen from Changwon National University graduate students who have trained for over 6 months. The scoring method with 9 hedonic scale (1: dislike extremely, 5: neither like nor dislike, 9: like extremely) was used. The samples were lightly grilled on a gas burner and served to panels. The sensory evaluation including odor, taste and overall acceptance were measured with duplication.

Statistical analysis

Statistical analysis was conducted with ANOVA to investigate relative correlations among items of each experiment, and the SPSS (Statistical Package, SPSS Inc.) system was used for the data analysis.

Results and Discussion

Determination of seasoning time for seasoned-dried Pacific saury

To determine seasoning time with seasoning recipe, salt content as a factor was measured in fillet because it could penetrate quickly to fish tissues due to its smallest molecule weight among ingredients of seasoning and simultaneously overall acceptance was performed after seasoning. The re-

sults of salt penetration rate analyzed are shown in Fig. 2. After 30 min of seasoning, salt penetration rate on seasoned fillet suddenly increased to 57.47% and slightly increased until 2 hrs of seasoning. From 2 hrs of seasoning time (84.48%), the salt penetration rate was almost maintained until 5 hrs. As the result of overall acceptance (Table 2), 3 hrs of seasoning time had the highest score (7.1) and 2 hrs, 5 hrs, 4 hrs and 6 hrs were followed in order. However, 3 hrs of seasoning was not significantly different with 2 hrs and 5 hrs though higher than the others. Therefore, for fast processing treatment, seasoning time was determined 2 hrs by the salt penetration rate and sensory evaluation.

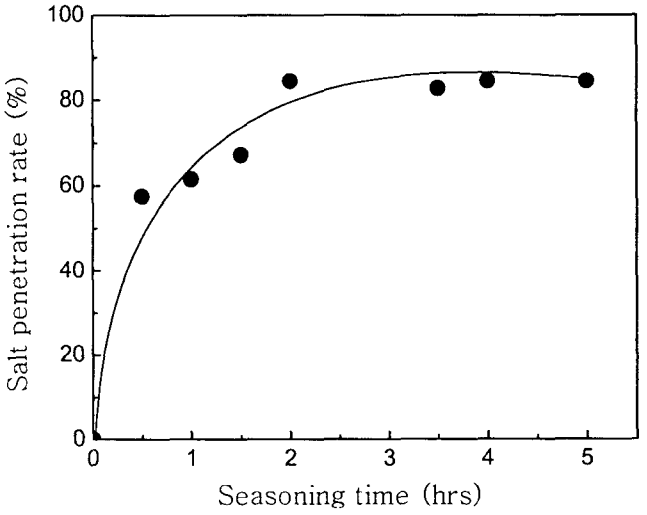

Fig. 2. Salt of penetration rate of seasoned Pacific saury.

Table 2. Results of overall acceptance for determination of seasoning time[1)]

	Seasoning time (hrs)				
	2	3	4	5	6
Overall acceptance	6.8[a]	7.1[a]	6.2[b]	6.6[ab]	5.6[c]

[1)] Sensory evaluation was performed by 9 panelists with 9 hedonic scale (1: dislike extremely, 5: neither like nor dislike, 9: like extremely) (n=2).

[a~c] Means with the same letters in superscripts are not significantly different ($p<0.05$).

Determination of drying time for seasoned-dried Pacific saury

To determine optimal drying time of seasoned Pacific saury in a hot-air dryer (40℃, air velocity: 1.4 m/sec, humidity: 69%), moisture contents were analyzed in one hour interval during drying, and drying curve were obtained (Fig. 3, 4). The moisture existed in sample were dried by two steps, namely constant rate drying and falling rate drying.

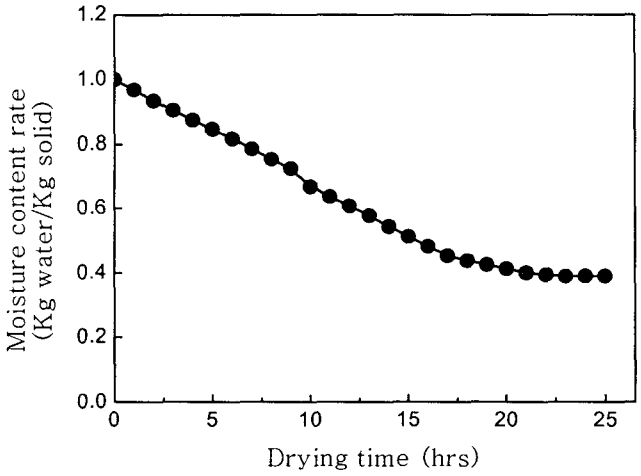

Fig. 3. Moisture contents of seasoned-dried Pacific saury during hot-air drying at 40℃.

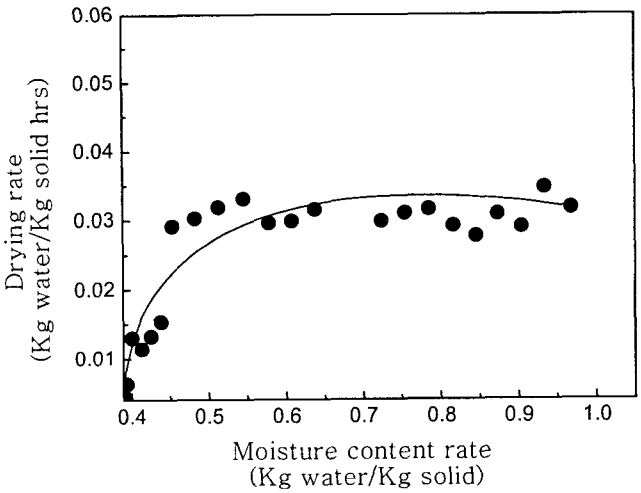

Fig. 4. Drying curve of seasoned-dried Pacific saury during hot-air drying at 40℃.

Moisture content of fillet was relatively dried with constant drying rate from the start of drying to 17 hrs, but the decrease of rate took place after 17 hrs of drying time. Accordingly, constant rate drying period could be by 17 hrs (critical moisture content) and falling rate drying period could be from 17 hrs. After that, moisture content slightly decreased until 23 hrs (24.70%) and then constantly maintained after 23 hrs. Therefore 23 hrs was decided for

drying time for processing of seasoned-dried products.

Determination of soaking time in liquid smoke for seasoned-dried Pacific saury

In order to determine optimal soaking time in liquid smoke, total acidity was measured as a factor because acidity represents one of properties of liquid smoke. The content of total acidity of fillet soaked in liquid smoke were shown in Fig. 5, and simultaneously sensory evaluation (Table 3) were followed. By material of company which produces liquid smoke used in this study, optimal concentration of liquid smoke applied to any products were decided as 5% liquid smoke. As a result of determination of the content of total acidity, the content of total acidity in fillet itself was 0.54%, and after fillet was soaked into liquid smoke, the contents of its total acidity slightly increased to 0.65% in 5 sec of soaking time and almost maintained from 10 sec and 20 sec with 0.71~0.73% range. At the same time, taste and overall acceptance in each soaking time were performed, the results of sensory evaluation in products treated with liquid smoke showed higher scores than those treated with seasoning only. In the products treated with liquid smoke, the product soaked for 5 sec showed the highest score, but not significantly different with 10 sec in both taste and overall acceptance. However, when liquid smoke applied to products, it might have weak effects due to its incomplete penetration to fillet meat referred to Fig. 5. In addition, if a product soaked in liquid smoke for a long time, the taste of the product might have bitter taste affected by liquid smoke. Therefore, 10 sec of soaking time was set because liquid smoke completely penetrated to fillet meat and showed high scores in sensory evaluation.

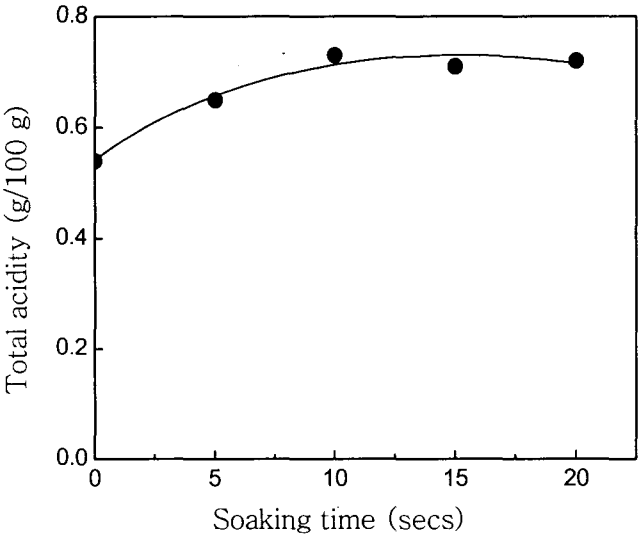

Fig. 5. Total acidity contents of seasoned Pacific saury for soaking in 5% (v/v) liquid smoke.

Table 3. Results of sensory evaluation of seasoned-dried Pacific saury according to soaking time in 5% (v/v) liquid smoke[1)]

Sensory items	Control[2)]	Soaking time (sec)			
		5	10	15	20
Taste	6.17[b]	7.50[a]	7.33[a]	5.78[b]	7.28[a]
Overall acceptance	6.28[b]	7.50[a]	7.33[a]	6.17[b]	6.72[ab]

[1)] Sensory evaluation was performed by 9 panelists with 9 hedonic scale (1: dislike extremely, 5: neither like nor dislike, 9: like extremely) (n=2).
[2)] Seasoning only.
[a~b] Means with the same superscripts in each row are not significantly different ($p<0.05$).

Proximate composition and VBN contents of products

Proximate compositions of raw sample and the 3 seasoned-dried products are shown in Table 4. Moisture content of raw fish was 71.7%, and the contents of the 3 types of dried products were totally 19.6~24.4% range in which 47.4~52.2% range was reduced, whereas those of crude protein, crude fat and crude ash relatively increased after drying. The contents of proximate compositions in this study were similar to those in a previous study (Park et al., 1981b) which moisture contents for raw and dried Pacific saury, respectively, and the changes of the rest compositions after drying for 30 hrs were also in similar trends. In the comparison of seasoned-dried products, the moisture content in T2 was higher than those of C and T1. This difference might be caused by different processing conditions. The contents of total sugar in C, T1 and T2 were 13.65%, 14.58% and 14.02%, respectively, and the contents of ash in 3 seasoned-dried products were in 5.98~6.75% range.

The contents of VBN (Table 4) in raw sample (7.13 mg/100 g) decreased to 5.96 mg/100 g after washing

Table 4. Proximate compositions and volatile basic nitrogen (VBN) contents of raw and seasoned-dried Pacific saury[1] (g/100 g)

	Raw material	After[2] washing	C	T1	T2
Moisture	71.7±0.1		19.6±0.1	19.7±0.1	24.4±0.1
Crude protein	21.5±0.1		47.7±0.1	46.3±0.1	42.9±0.1
Crude lipid	4.4±0.1		11.9±0.1	12.6±0.1	12.3±0.1
Total sugar			13.7±0.4	14.6±0.6	14.0±0.2
Crude ash	1.9±0.0		6.8±0.1	6.5±0.0	6.0±0.1
VBN (mg/100 g)	7.13±0.12	5.96±0.20	32.30±0.10	28.95±0.08	28.36±0.00

[1] Mean value ± S.D. (n=3).
[2] Refer to comment in Fig. 1.

and then somewhat increased to 6.13 mg/100 g after seasoning, but the whole VBN contents of all samples were very low amounts. The decrease of the content after washing is thought that soluble VBN was drained out during the course of washing. In the seasoned-dried products, C had the highest content, while T1 and T2 had lower. Lee et al. (1985) reported that low VBN content of dried product treated with liquid smoke is caused by antiseptic effect of liquid smoke. Furthermore, the VBN content (83.2 mg/100 g) of dried Pacific saury processed by Park et al. (1981b) was represented much higher than those of our dried products. This is thought because of difference of hot-air drying conditions, namely 51℃ for 30 hrs and 40℃ for 23 hrs in Park et al. (1981b) and in our study, respectively.

Histamine contents of products

The histamine contents of raw saury and the 3 sea-soned-dried products are shown in Table 5. Histamine was known as one of substance of allergenic food poisoning and readily occurred when we have intaken dark fleshed fish including tuna, sardine and Pacific saury (Park et al., 1981b). As the contents of histamine in raw and samples after washing and seasoning were in a range of 1.50~3.89 mg/100 g and 15.33~26.99 mg/100 g for the 3 dried products, it could be safe in the sanitary aspect because the contents of the raw and the dried samples measured were much lower compared to tolerance limit of intake (100 mg/100 g) (Arold and Brown, 1978). However, the histamine content of T2 was higher than the others, and further study should be conducted in this part. In addition, Park et al. (1981b) reported that the histamine content of dried product using hot-air drying were lower than those using other drying methods, as is due to inhibition or gradual decline of growth of bacteria producing histamine by heat treatment for a long time in accordance with no formation of histamine over 30℃, and Hibiki and Simidu (1958) also reported that bacteria producing histamine was declined by heat treatment of 60℃.

Table 5. Histamine contents in raw and seasoned-dried Pacific saury[1] (mg/100 g)

	Raw material	After[2] washing	C	T1	T2
Histamine	3.89±0.08	1.50±0.09	19.77±0.91	15.33±0.56	26.99±0.30

[1] Mean value ± S.D. (n=3).
[2] Refer to comment in Fig. 1.

Water activity and pH of products

The Water activity (Aw) and pH of raw and seasoned-dried products are shown in Table 6. The Aw of raw sample and 3 dried products were 0.937 and 0.719~0.735 range, respectively. This Aw range of dried products is known as intermediate moisture field in which microorganisms including bacteria and yeast could generally not grow and, therefore, plays important role to storage stability (Park et al., 1994).

Table 6. Results of chemical analysis in seasoned-dried Pacific saury[1]

	Raw material	C[2]	T1	T2
Aw	0.937	0.735	0.720	0.719
pH		6.45	6.42	6.27
TBA (mg/kg)[3]		16.67±0.14	10.38±0.07	6.26±0.25
POV (meq/kg)		43.23±0.74	12.03±0.28	13.53±0.90
Viable cell count (CFU/g)		3.6×10^6	5.5×10^6	2.1×10^6

[1] Mean value ± S.D. (n=3).
[2] Refer to comment in Fig. 1.
[3] Thiobarbituric acid reactive substances.

The pH of C and T1 were 6.45 and 6.42, respectively, while 6.27 for T2 were relatively lower. The lower value of pH is considered that components of liquid smoke such as acids and phenols were absorbed on the surface of products and then penetrated (Sink and Hsu, 1977), and this result might affect the microbial growth during storage of products.

TBA and POV of products

For comparison of antioxidative effects among seasoned-dried products, TBA and POV were carried out in this study (Table 6). The TBA values of C, T1 and T2 showed 16.67 mg/kg, 10.38 mg/kg and 6.26 mg/kg, respectively, and especially the content of T2 were lower than that of T1, treated with antioxidant. It was positively insured that the effect of liquid smoke for inhibiting lipid oxidation is predominant. In case of POV, T1 (12.03 meq/kg) and T2 (13.53 meq/kg) were significantly lower compared to C (43.23 meq/kg). These trends were reported by Lee et al. (1986a) that studied about seasoned-dried sardine, and by some previous studies (Lee et al., 1982a; Hollenbeck, 1979). The lower POV in the products treated with liquid smoke is due to effect of phenol and its derivatives. Moreover, several researches reported on the effectiveness of liquid smoke on the suppressing lipid oxidation in the processing of seasoned squid (Lee et al., 1985), ark shell and baby clam (Lee et al., 1986b) and canned oyster (Lee et al., 1983).

Viable cell count of products

The viable cell counts of the 3 products in this study (Table 6) were relatively higher than those of seasoned-smoked sea-eel products (Park et al., 1986). However, microorganism existed in most of the products having the extents of water activity in which they could not grow. It is considered that microorganism might exist on the surface of dried products due to the result of no packaging. On the other hand, the viable cell count in T2 was lower than those in the others and this is thought due to acids and phenols in liquid smoke as antibacterial action (Tilgner and Daun, 1968).

Color value and sensory evaluation

The results of color values and sensory evaluations of 3 seasoned-dried products are shown in Table 7. The L-value and a-value of C were significantly lower than those of T1 and T2, and T1 was significantly lower in b-value. In the ΔE, C was significantly higher than the others. Lee et al. (1986 a) reported that the seasoned-dried sardine treated with liquid smoke had lower L-value than control and another product treated with sodium erythorbate as an antioxidant. However, significant changes were not estimated among samples, and this might be related with water activity of products in which Maillard reaction might easily develop in this range (Troller and Christian, 1978), so these extreme browning reaction during drying was already led to no significant changes among 3 dried products.

Table 7. Results of color value and sensory evaluation of seasoned-dried Pacific saury

		C[1]	T1	T2
Color value[2]	L	21.33[b]	23.07[a]	22.43[a]
	a	0.18[b]	1.02[a]	0.91[a]
	b	1.57[a]	0.81[b]	1.58[a]
	ΔE	75.46[a]	73.72[b]	74.37[b]
Sensory evaluation[3]	Odor	4.78[c]	5.67[b]	8.11[a]
	Taste	4.78[b]	7.11[a]	7.00[a]
	Overall acceptance	4.67[b]	6.89[a]	7.22[a]

[1] Refer to comment in Fig. 1.

[2] L: Measures lightness and varies from 100 for perfect white to zero black (Standard plate: 96.77).
a: Measures redness when plus, gray when zero and greenness when minus (Standard plate: −0.17).
b: Measures yellowness when plus, when zero, and blueness when minus (Standard plate: −0.20).
ΔE: $\sqrt{\Delta L^2+\Delta a^2+\Delta b^2}$

[3] Sensory evaluation was performed by 9 panelists with 9 hedonic scale (1: dislike extremely, 5: neither like nor dislike, 9: like extremely) (n=2).

[a~c] Means with the same letter in each row among samples in each item are not significantly different ($p<0.01$).

In the tests of odor, taste and overall acceptance (Table 7), T2 had significantly higher score than C and T1 in odor, and T1 and T2 significantly had better taste and overall acceptance than C. Accordingly, we obtained the consequence which the product treated with liquid smoke has high preference by sensory evaluation.

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