

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

4. Quality Stability of Seasoned-Dried Pacific Saury Treated with Liquid Smoke During Storage

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As a series of studies on improving quality of seasoned-dried Pacific saury, storage stability of seasoned-dried saury treated with liquid smoke (T2 product) was examined during storage at ambient temperature ($19 \pm 5^\circ\text{C}$), comparing with control (C, seasoning only) and T1 (treatment of 0.05% Rosemary as a antioxidant). The histamine contents (15.33~32.21 mg/10) g) of 3 seasoned-dried products were much lower than tolerance limit of intake during 80 days of storage. The water activity of 3 seasoned-dried products was in range of 0.692~0.735. The pH of T2 showed relatively lower than the others during storage. The POV of T2 was slightly higher until 30 days, but was lower after 45 days compared with T1. The TBA value and viable cell count of T2 were the lowest among the samples during storage. The color values of 3 seasoned-dried products were not significantly different during storage. The sensory scores of T2 was the highest than those of T1 and C during storage. Therefore, liquid smoking method was a useful technique to extend shelf-life and retain good sensory quality of seasoned-dried Pacific saury.

Key words: Seasoned-dried, Pacific saury, Liquid smoke, Storage stability

Introduction

Smoking techniques have been used for centuries as a method for preserving meat and fish. Smoking impregnates the high protein food with aromatic compounds which lend flavor and color to the food, and also play a bacteriostatic and antioxidant role (Bratzler et al., 1969; Poulter, 1988). Traditional smoking with pyrolytic flue gases is not very favorable as it generates polyaromatic hydrocarbons (PAHs). These PAHs are known as carcinogen and a major class of environmentally hazardous organic compounds. An alternative method to flue-gas smoking is the use of liquid smoking, which is not a new method and has been used for more than 30 years as preserver and aromatizer of meat and fish

(Olsen, 1976).

On the other hand, Pacific saury highly containing the functional fatty acids such as EPA and DHA has not well been used as processing material because of its properties of weak tissue and high lipid content. So, Pacific saury has only been processed to canned food with limited processing methods, and most of it have mainly been used as raw fish on the markets (Lee et al., 1993). For the utilization of Pacific saury as a high added value fish, therefore, we previously applied the liquid smoking as a method for the quality improvement and shelf-life extension of seasoned-dried Pacific saury (Cha et al., 2001).

The objective of this study is to examine the storage stability of seasoned-dried product treated with liquid smoke during storage, as a series of studies on improving quality of seasoned-dried Pacific saury.

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Materials and Methods

Materials

Pacific saury, *Cololabis saira* (28 ± 2 cm in length, 93 ± 6 g in weight), which had been 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 hr.

The liquid smoke used in seasoned-dried products was selected Scansmoke PB 2110 (P. Broste A/S, Denmark) as described in previous paper (Cha et al., 2001).

Processing of seasoned-dried Pacific saury

The processing of seasoned-dried Pacific saury with seasoning, which was composed of sugar 12.21%, salt 1.74%, MSG 1.03% and sorbitol 3.02% to Pacific saury fillet (w/w), are shown in Fig. 1. More details of processing procedure have been described in previous paper (Cha et al., 2001). Three products completely processed were packaged with 300 g each unit in a polypropylene film (0.08 mm thickness)

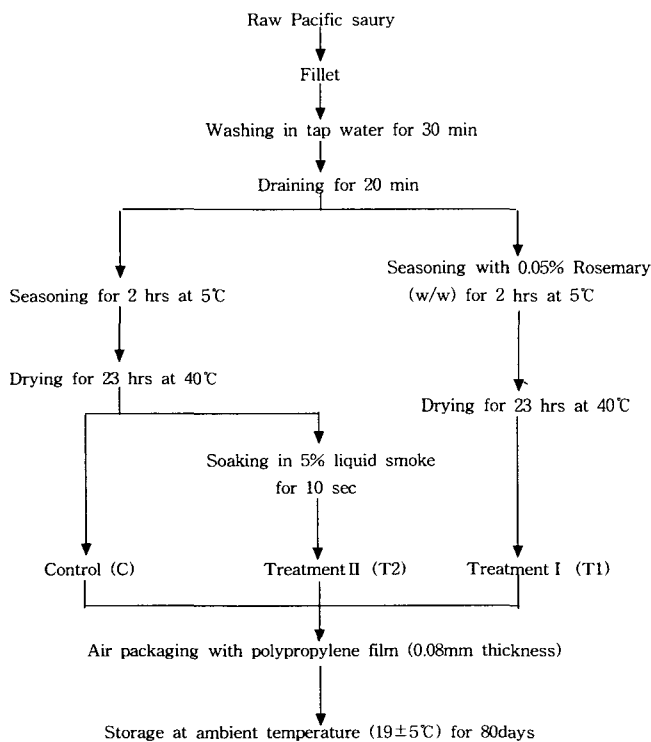


Fig. 1. Flow sheet of processing conditions for seasoned-dried Pacific saury.

and stored at ambient temperature ($19 \pm 5^\circ\text{C}$) during 80 days.

Analysis of proximate composition and histamine contents

The proximate composition including moisture, total sugar (Bertrand method), crude protein (semi-micro Kjeldahl method), crude lipid (Soxhlet method) and crude ash were determined by A.O.A.C method (1990). Histamine contents was followed by a method of KSFSN (2000).

Analysis of water activity (A_w), pH, volatile basic nitrogen (VBN), viable cell count

A_w was determined using Digital Water Activity analyzer (Novasina, CH-8808, Pfaffikon, Swiss). The pH was determined using a pH meter (pH/ion meter DP-880, Dongwoo Medical System, Korea) as described in previous paper (Cha et al., 2001).

The contents of VBN and viable cell count were determined by Conway micro-diffusion method (Ministry of Social Welfare of Japan, 1960) and standard plate count method (Collins and Lyne, 1985), respectively.

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

POV and TBA value were determined by the method of A.O.C.S (1990) and steam distillation method (Tarladgis et al., 1960) described in previous paper (Cha et al., 2001).

Color value

The samples for measuring color value including L, a, b, and ΔE -value were cut into a size ($3 \times 3 \times 0.4$ cm³) and determined by using a color difference meter (Minolta, CM-3500d, Japan) described in previous paper (Cha et al., 2001).

Sensory evaluation

Sensory evaluation was performed by 9 sensory panels chosen from CNU graduate students who have been 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

Changes of proximate compositions during storage

The changes of proximate compositions in seasoned-dried products during storage are shown in Table 1. The moisture content of raw sample was 71.7%, and the moisture contents of C, T1 and T2 during storage were in the ranges of 18.6~19.6%, 19.1~19.7% and 19.8~24.4%, respectively. The contents of moisture slightly decreased with increasing storage time, while the contents of crude protein and lipid increased. These decrease of moisture in seasoned-dried products during storage might be due to evaporation of moisture contained in products through packaging film (Lee et al., 1982a). The crude ash contents of C, T1 and T2 were in the ranges of 6.3~6.8%, 6.5~6.8% and 5.3~6.0%, res-

pectively, and the total sugar contents of all seasoned-dried products were in the range of 12.3~14.7% during 80 days of storage.

Changes of histamine contents during storage

The changes of histamine contents during storage are shown in Table 2. In the course of processing, the histamine contents in raw and samples after washing and seasoning were 3.89 mg/100 g, 1.50 mg/100 g and 2.03 mg/100 g, respectively. Especially, the decrease of content after washing might be because soluble histamine was drained out during the course of washing (Park et al., 1986). The contents of histamine in 3 seasoned-dried products were in the range of 15.33~32.21 mg/100 g, and the changes of histamine contents increased with increasing storage period. But because the contents of all seasoned-dried products measured during storage were much lower compared to tolerance limit of intake (100 mg/100 g) (Arold and Brown, 1978), so it could be safe in hygienical aspect. However, the histamine content of T2 was higher than the others, and further study should be needed in future.

Changes of water activity (A_w), pH and volatile basic nitrogen (VBN) contents during storage

The changes of A_w during storage are shown in

Table 1. Changes of proximate compositions of raw and seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$) (g/100 g)

	Raw material	C1 ¹⁾			T1			T2		
		0 day	45 days	80 days	0 day	45 days	80 days	0 day	45 days	80 days
Moisture	71.7 \pm 0.1 ²⁾	19.6 \pm 0.1	19.4 \pm 0.0	18.6 \pm 0.0	19.7 \pm 0.1	19.5 \pm 0.1	19.1 \pm 0.0	24.4 \pm 0.1	21.6 \pm 0.0	19.8 \pm 0.1
Crude protein	21.5 \pm 0.1	47.7 \pm 0.1	48.0 \pm 0.0	48.7 \pm 0.0	44.3 \pm 0.1	45.1 \pm 0.1	45.6 \pm 0.0	42.9 \pm 0.1	45.9 \pm 0.0	47.9 \pm 0.1
Crude lipid	4.4 \pm 0.1	11.9 \pm 0.1	12.6 \pm 0.0	13.4 \pm 0.5	12.6 \pm 0.1	13.6 \pm 0.0	14.0 \pm 0.1	12.3 \pm 0.1	12.9 \pm 0.1	12.8 \pm 0.1
Total sugar		13.7 \pm 0.4	13.1 \pm 0.1	12.3 \pm 0.1	14.6 \pm 0.6	14.7 \pm 0.1	14.2 \pm 0.2	14.0 \pm 0.2	14.0 \pm 0.1	13.7 \pm 0.0
Crude ash	1.9 \pm 0.0	6.8 \pm 0.1	6.3 \pm 0.1	6.7 \pm 0.1	6.5 \pm 0.0	6.8 \pm 0.0	6.7 \pm 0.0	6.0 \pm 0.1	5.3 \pm 0.0	5.3 \pm 0.0

¹⁾ Refer to comment in Fig. 1.

²⁾ Mean value \pm S.D. (n=3).

Table 2. Changes of histamine contents in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$) (mg/100 g)

Storage days	Raw material	After ¹⁾ washing	After seasoning	C	T1	T2
0	3.89 \pm 0.08 ²⁾	1.50 \pm 0.09	2.03 \pm 0.02	19.77 \pm 0.91	15.33 \pm 0.56	26.99 \pm 0.30
45				21.43 \pm 0.22	18.26 \pm 0.41	29.01 \pm 0.12
80				27.35 \pm 0.09	25.49 \pm 0.11	32.21 \pm 0.03

¹⁾ Refer to comment in Fig. 1.

²⁾ Mean value \pm S.D. (n=3).

Fig. 2. The range of A_w of all seasoned-dried products was 0.692~0.735, in which bacteria could generally not grow (Park et al., 1994), and is also known that the rate of lipid oxidation (Dockworth, 1975) and nonenzymatic browning (Park et al., 1994) rapidly increased. During storage, significant differences were not observed among 3 products, but 0.719~0.735 of A_w for 3 products in 0 day somewhat decreased up to 0.692~0.713 in 80 days of storage. This decrease of A_w was similar to results of Lee et al. (1982a) which referred to influence of moisture decrease during storage.

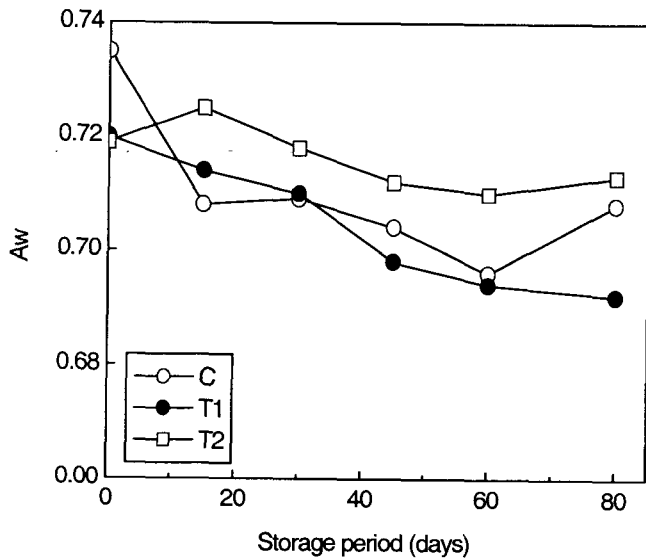


Fig. 2. Changes of water activity (A_w) in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

The changes of pH during storage are shown in Fig. 3. The pH (6.42~6.45 range) of C and T1 in 0 day suddenly decreased up to the range of 6.25~6.27 in 15 days and then slightly increased up to the range of 6.26~6.32 in 80 days, which was similar to a result of Sink and Hsu (1977). Hamm (1966) reported that the decrease trend at initiative step might be caused by activities of seasoning to protein tissues, and after that, the increase trend might be due to changes of electric charges generated from broken peptide chains of myofibrillar protein.

The change of T2 was similar with those of C and T1, however pH of T2 (6.08~6.27 range) showed relatively lower, which might be caused by acids and phenols, components of liquid smoke (Sink and Hsu, 1977). So these low pH of T2 might

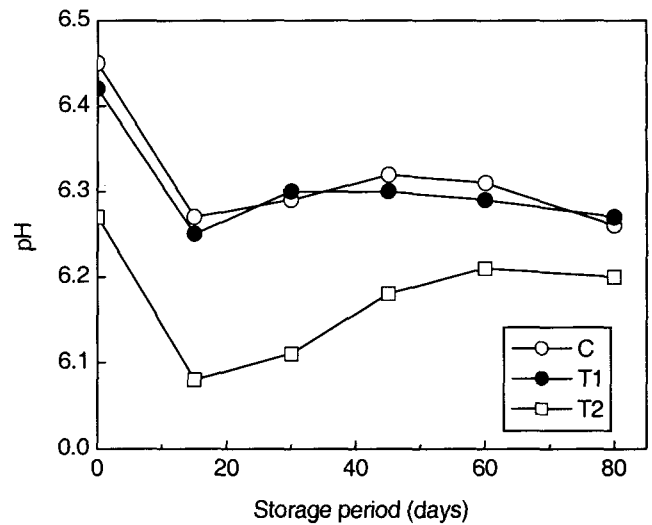


Fig. 3. Changes of pH in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

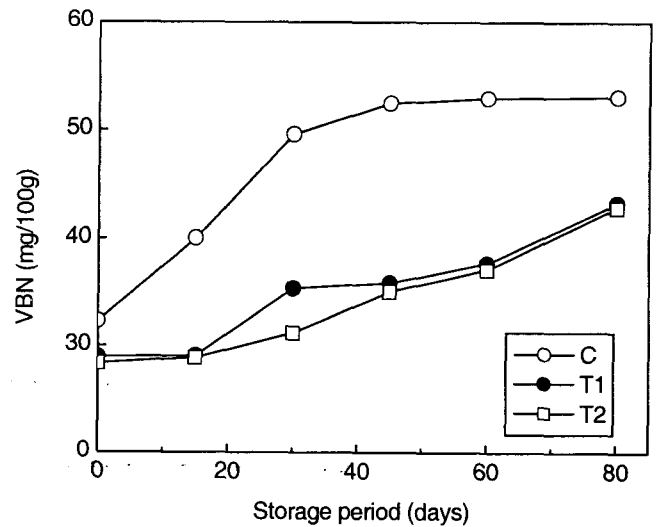


Fig. 4. Changes of volatile basic nitrogen (VBN) in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

affect the microbial growth existing in products during storage.

The changes of VBN contents are shown in Fig. 4. With increasing storage period, VBN contents of all seasoned-dried products slightly increased, and C had the highest contents, and T1 and T2 were followed in order. The VBN content of C (32.30 mg/100 g) in 0 day rapidly increased up to 49.59 mg/100 g in 30 days and then slightly increased up to 53.08 mg/100 g in 80 storage days, whereas those of T1 and T2 (28.36~28.95 mg/100 g range) in 0 day

slowly increased up to the range of 42.92~43.29 mg/100 g in 80 days. However, these increase trends in 3 products with storage period should be due to various factors, namely generation of trimethylamine (Zar.a, 1970), originated by oxidation of phospholipid, and generation of ammonia or amines originated by degradation of N-containing compounds such as amino acids (Park et al., 1994). On the other hand, T2 treated with liquid smoke showed lower than the others (C and T1) during storage. This trend should be inferred from the report of Lee et al. (1986), which studied about vacuum packed seasoned-dried sardine, as antiseptic effect of liquid smoke.

Changes of thiobarbituric acid (TBA) and peroxide value (POV) during storage

The changes of TBA values during storage are shown in Fig. 5. The TBA values of all seasoned-dried products increased up to 30 days and then decreased continuously. In the products, the TBA value of C was the highest, and T1 and T2 were followed in order. This is similar to results of Kim (1972) in which TBA values of dried Alaska pollack during storage increased up to 30 days and then decreased slowly, and Byun et al. (1978) also reported that TBA values of dried sea eel during storage increased up to 20 days and then decreased. Laleye et al. (1984) and Gokalp et al. (1983)

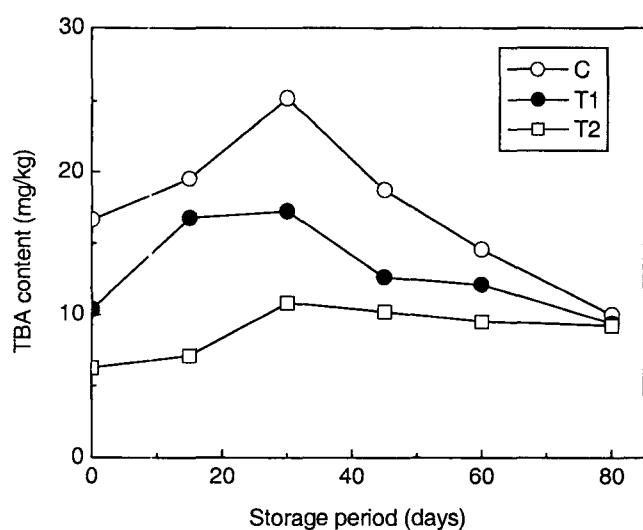


Fig. 5. Changes of thiobarbituric acid (TBA) content in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

reported that abundant malonaldehyde, which react with thiobarbituric acid (TBA), are generated in initiative step of storage, but TBA values during long-term storage decreased because malonaldehyde are so reactive and easily react with carbonyl compounds, amino acids and urea after constant times. In general, TBA is known as analytical method at the initial stage of lipid oxidation, and accordingly, it might be incorrect that TBA is simply used in long-termed experiments with samples, having high lipid content.

In the changes of POV (Fig. 6) of each product during storage, generally all samples showed increase trends with storage period, and POV (43.23 meq/kg) of C in 0 day highly increased up to 88.34 meq/kg in 80 days, whereas T1 (12.03~74.65 meq/kg) and T2 (13.53~58.71 meq/kg) showed slight increase. These results were demonstrated that liquid smoke was very effective on the restraint of lipid oxidation as same as antioxidant by comparing of POV of T2 and T1. According to Lee et al. (1986) which they measured POV of vacuum packed seasoned-dried sardines, POV of control treated with only seasoning increased up to maximum in 40 days and then slightly decreased, while the products treated with sodium erythorbate and another one treated with liquid smoke constantly increased with increasing storage period. But POV of the products in the paper of Lee et al. (1986) were lower than those of this study, and this is thought that sea-

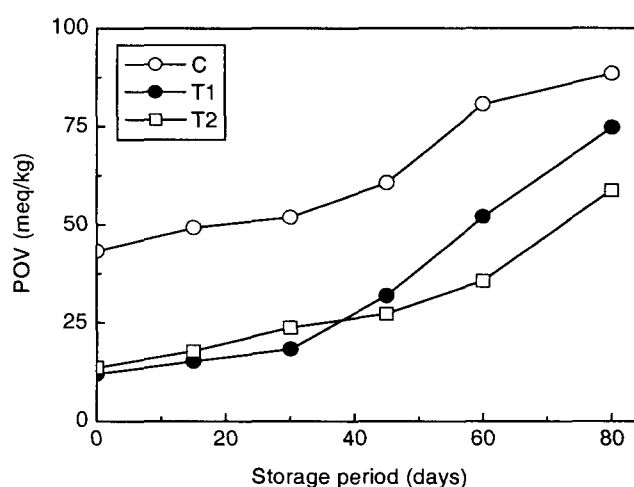


Fig. 6. Changes of peroxide value (POV) in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

soned-dried Pacific saury products was longer to be exposed to heat and air than dried sardine products, and also the latter had vacuum package to extend shelf-life. Also, in POV analysis by comparative experiment, the antioxidative effect of liquid smoke was proved when applied to sea food products.

Changes of viable cell count during storage

The changes of viable cell counts during storage are shown in Fig. 7. The viable cell count of C in 0 day increased up to 15 storage days, decreased up to 45 days and then increased (2.7×10^6 CFU/g) slowly, while those of T1 and T2 decreased up to 30 days and then increased ($5.9 \times 10^5 \sim 1.7 \times 10^6$ CFU/g range) slightly. At the initial stage of storage, these decrease of microbe number might be caused by Rosemary and liquid smoke used in this study. Several researchers have described antimicrobial activities of antioxidants having flavonoids or phenolic compounds against foodborne pathogenic bacteria (Ayaz, 1980; Robach and Pierson, 1979), yeasts (Eubanks and Beuchat, 1983), and molds (Chang and Branen, 1975). The viable cell count of T2 was the lowest, and this is might be antibacterial effects by liquid smoke. With increasing storage period, increase of microorganisms might be due to the growth of mold which cause spoilage of dried products (Park et al., 1994).

Changes of color values during storage

Table 3. Changes of color values¹⁾ in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$)

Storage days	L			a			b			ΔE		
	C ²⁾	T1	T2	C	T1	T2	C	T1	T2	C	T1	T2
0	^C 21.33 ^b	^C 23.07 ^a	^C 22.43 ^a	^D 0.18 ^b	^{BC} 1.02 ^a	^{CD} 0.91 ^a	^{CD} 1.57 ^a	^D 0.81 ^b	^C 1.58 ^a	^A 75.46 ^a	^C 73.72 ^b	^A 74.37 ^b
15	^B 23.21 ^a	^C 23.12 ^a	^C 22.65 ^a	^C 0.96 ^a	^C 0.93 ^a	^D 0.75 ^a	^{BC} 1.85 ^a	^C 1.51 ^a	^C 1.54 ^a	^B 73.62 ^a	^C 73.70 ^a	^A 74.17 ^a
30	^A 24.51 ^a	^B 23.74 ^b	^{BC} 23.22 ^b	^A 1.65 ^b	^A 2.45 ^a	^{BC} 1.25 ^b	^A 3.13 ^a	^{AB} 2.47 ^b	^C 1.90 ^c	^C 72.35 ^b	^D 73.12 ^{ab}	^{AB} 73.58 ^a
45	^C 21.87 ^b	^A 24.58 ^a	^C 22.81 ^b	^D 0.27 ^c	^{BC} 1.37 ^a	^{CD} 0.96 ^b	^D 0.87 ^b	^{BC} 2.18 ^a	^C 1.80 ^a	^A 74.89 ^a	^E 72.24 ^b	^{AB} 73.99 ^a
60	^A 24.50 ^a	^D 21.26 ^b	^B 24.18 ^a	^B 1.23 ^b	^C 0.79 ^b	^A 1.64 ^a	^{AB} 2.44 ^b	^C 1.78 ^c	^A 3.37 ^a	^{AB} 74.29 ^b	^A 77.50 ^a	^A 74.66 ^b
80	^{AB} 24.29 ^b	^B 23.72 ^b	^A 25.80 ^a	^B 0.76 ^a	^{AB} 1.82 ^a	^{AB} 1.44 ^a	^{BC} 2.18 ^a	^A 2.72 ^a	^B 2.58 ^a	^{AB} 74.50 ^a	^B 75.11 ^a	^B 73.01 ^b

¹⁾ L: Measures lightness and varies from 100 for perfect white to zero black (Standard plate: 97.56).
a: Measures redness when plus, gray when zero and greenness when minus (Standard plate: -0.16).
b: Measures yellowness when plus, gray when zero and blueness when minus (Standard plate: -0.30).
 $\Delta E: \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$

²⁾ Refer to comment in Fig. 1.

^{a-c} Means with the same letter in each row among samples in each item are not significantly different ($p < 0.05$).

^{A-E} Means with the same letter in column of each sample in each item are not significantly different with increasing storage period ($p < 0.05$).

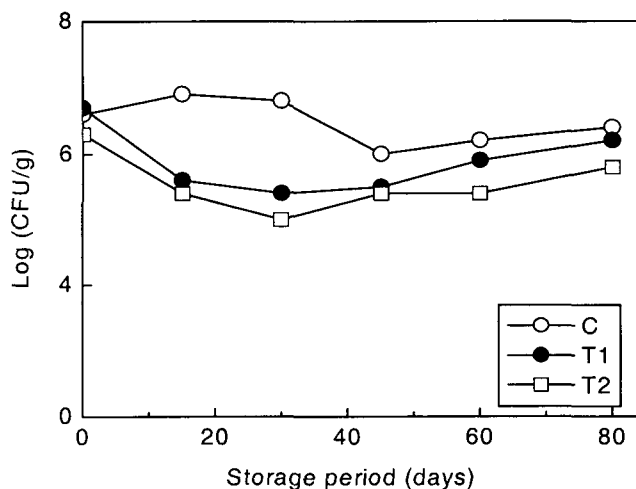


Fig. 7. Changes of viable cell counts in seasoned-dried Pacific saury during storage at ambient temperature ($19 \pm 5^\circ\text{C}$).

The changes of color values in seasoned-dried Pacific saury during storage are shown in Table 3. The L-value of C, T1 and T2 were not significantly different with the ranges of 21.33~24.51, 21.26~24.58 and 22.43~25.80 during storage, respectively. Even though a- and b-values of 3 seasoned-dried products were significantly changed with increasing storage period ($P < 0.05$), the span of those range was small. ΔE -value of C, T1 and T2 were in the ranges of 72.35~75.46, 72.24~77.50 and 73.01~74.66 during storage, respectively. This is considered to be related with water activity of products in which Maillard reaction might easily occur in this range (Troller

and Christian, 1978), so these extreme browning reaction during drying was already led to no significant changes among 3 products during storage. According to Lee et al. (1984, 1986), which studied about retort pouched-seasoned oyster and seasoned-dried sardine, a- and b-values of the product treated with liquid smoke were higher than that of control during storage, and these are thought due to interaction between amino acids and carbonyl compounds in fish and liquid smoke.

Changes of sensory quality during storage

The results of sensory evaluation for odor, taste and overall acceptance in seasoned-dried Pacific saury during storage are shown in Table 4. In the case of odor and overall acceptance, T2 treated with liquid smoke was significantly predominant compared to C and T1 during storage. Two products T1 and T2 had significantly good taste compared to C during storage. Most of sensory characteristics of C and T1 decreased under the 5.0 (neither like nor

Table 4. Changes of sensory quality¹⁾ in seasoned-dried Pacific saury during storage at ambient temperature (19 ± 5°C)

Storage days	Odor			Taste			Overall acceptance		
	C ²⁾	T1	T2	C	T1	T2	C	T1	T2
0	^A 4.78 ^c	^A 5.67 ^b	^A 8.11 ^a	^B 4.78 ^b	^A 7.11 ^a	^A 7.00 ^a	^B 4.67 ^b	^A 6.89 ^a	^A 7.22 ^a
15	^A 5.11 ^b	^A 5.78 ^b	^B 7.33 ^a	^A 5.00 ^b	^{BC} 5.00 ^b	^A 6.89 ^a	^A 6.56 ^a	^B 5.00 ^b	^A 7.00 ^a
30	^A 4.78 ^b	^A 4.89 ^b	^{BC} 7.11 ^a	^B 4.44 ^b	^B 5.89 ^a	^A 6.33 ^a	^B 4.67 ^c	^B 5.11 ^b	^A 6.44 ^a
45	^A 4.78 ^b	^A 5.22 ^b	^A 8.11 ^a	^B 4.11 ^b	^C 4.44 ^b	^A 6.44 ^a	^B 4.22 ^b	^B 4.67 ^b	^A 6.89 ^a
60	^B 3.33 ^c	^A 5.33 ^b	^C 6.56 ^a			^B 5.44			^B 5.67

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⁾ Refer to comment in Fig. 1.

^{a-c} Means with the same letter in each row among samples in each item are not significantly different (p<0.05).

^{A-C} Means with the same letter in column of each sample in each item are not significantly different with increasing storage period (p<0.05).

dislike) score in 30 and 45 days, respectively, while those of T2 showed over 5.0 score until 60 days. According to comments of panels, however, off-flavor in C and T1 started to happen in 45 days but not as much as affected their tastes, whereas T2 did not have off-flavor until 60 days. This is thought as masking effects of liquid smoke. But T2 in 60 days was hard to feel sweet taste of seasoned-dried products, which might be associated with decrease of taste compounds during storage. Also, their sensory texture was too tough to intake. In addition, with regard to increasing high values of TBA and POV and continuous microbial growth during storage, it was hard to intake T2 product in 60 days although it had high scores on sensory evaluation. As explained above, it might be implied that liquid smoke affected to extend shelf-life of seasoned-dried products by the results of sensory evaluation. Therefore, in order to extend shelf-life further studies should be conducted to improve sensory texture by optimal drying and inhibit lipid oxidation and microbial growth by vacuum packaging during storage.

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