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Storage Stability of Seasoned-Dried Pacific Saury (Imported Product) Treated with Liquid Smoke

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Abstract

In order to enhance suitable processing methods of imported Pacific saury, *Cololabis saira*, storage stability of seasoned-dried Pacific saury (imported product) treated with liquid smoke (T2 product) was compared with a control (C, seasoning only) and T1 (treatment of 0.05% BHT instead of liquid smoke). The histamine contents of 3 seasoned-dried products were within a stable range (9.08~12.08 mg/100 g) during storage. The water activities of all products were in the 0.698~0.755 range. The viable cell count of T2 was lower than those of C and T1 during storage. The change in color values of C, T1 and T2 were not significant with increasing storage period. The results of the sensory evaluation during storage showed that the shelf-life of T2 was extended to 60 days, while those of C and T1 were limited to up to 45 days.

Key words: smoked and seasoned-dried seafood, imported Pacific saury, liquid smoke, quality stability

INTRODUCTION

Dark fleshed fishes such as Pacific saury, mackerel, horse mackerel and gizzard shad are readily oxidized and hard to use for processing as raw materials due to their high lipid contents. So, 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 fishes on the market (1).

Therefore, in order to protect these nutritional substances and develop a new processing method on dark fleshed fishes, much research has been performed with various methods such as surimi (2), fish jelly product (kamaboko) (3) and microwave heating techniques (4). In addition, some research attempted to restrain oxidation and denaturation in lipid and protein of fatty fishes using cold-osmotic pressure dehydration method (5), a free-oxygen absorber (6) and the liquid smoking method (7). Among various methods, the liquid smoking method has been used in food processing as a means of preservation and flavoring for a long time (8), and several studies about application of liquid smoke were attempted to enhance quality stability of dried seafoods such as sardine (7), file fish (9) and baby clam (10) during seasoning treatment.

Therefore, if new research for extending shelf-life of dark fleshed fishes is successful, it could give lots of benefits in the field of sea food processing in the aspects of effective utilization of dark fleshed fishes. Among dark fleshed fishes, especially, Pacific saury is not suitable for processing because of its weak tissue. However, we attempted to set suitable processing conditions and storage stability of smoked and seasoned-dried Pacific saury using domestic products in previous papers (11,12). But the seasoning products of imported Pacific saury are known difficult to process because of its higher content of lipid than domestic one.

The objectives of this study are to examine storage stability of smoked and seasoned-dried product produced with imported Pacific saury.

MATERIALS AND METHODS

Materials

Pacific saury, *Cololabis saira*, (32±3 cm length, 110±5 g weight) which had caught in the North Pacific Ocean and frozen, were purchased from Changjin Trading Inc. (Masan, Korea). They were transferred to Food Processing Lab., Changwon National University (CNU), within 2 hr.

The liquid smoke used was Scansmoke PB 2110 (P. Broste A/S, Denmark), which was proven to have relatively higher contents of acids and phenols than the other products as described in a previous paper (13). This was donated from a product company and stored in a refrigerator (-3±1°C) until use.

Processing of smoked and seasoned-dried Pacific saury

The processing of seasoned-dried Pacific saury is shown in Fig. 1. First, frozen fishes were dipped in water to thaw out, 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 (Table 1) only and stood for 2 hr at 5°C. These

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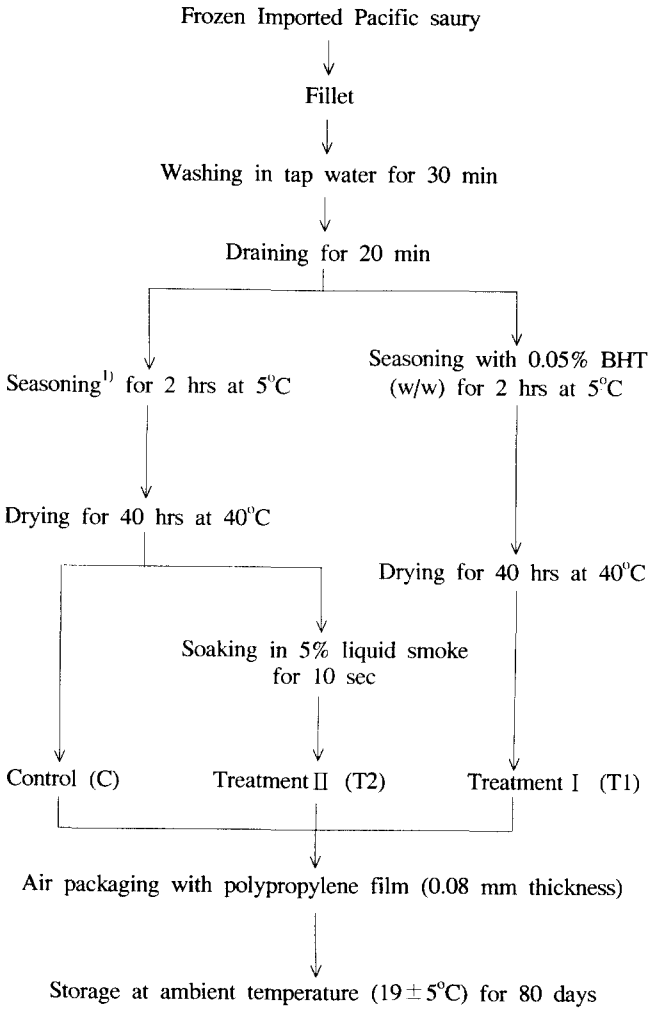

Fig. 1. Flow sheet of processing conditions for smoked and seasoned-dried Pacific saury (impotred product).
[1)]Seasoning recipes refer to comment in Table 1.

Table 1. Recipe of seasoning for processing of seasoned-dried Pacific saury (imported product)

	Ratio to fish (w/w)	% 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.

seasoned fillets (C) were set on trays and dried in a hot-air dryer (Dongyang Scientific Co. Ltd, Korea) for 40 hr at 40°C under the air velocity of 1.4 m/sec, at 69% humidity. During the drying, each fillet was turned over every 2 hrs and the trays were changed around in order to make equal drying conditions. Treatment II (T2) was soaked for 10 sec in 5% (v/v) liquid smoke (Scansmoke PB 2110, Denmark) after 26 hr drying. Treatment I (T1) was treated with seasoning including 0.05% BHT (w/w) before drying for 40 hr. After processing the three products were packaged, 300 g each unit, in a polypropylene film (0.08 mm film thickness) and stored at ambient temperatures (19±5°C) for 80 days.

Analysis of proximate composition

The content of 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 (14).

Analysis of histamine contents

Histamine contents was followed by a method of the Korean Society of Food Science and Nutrition (KSFSN) (15). Ten gram of homogenized raw fish (2 g of dried sample) was taken into a mortar, blended for 5 min with 20 mL of distilled water and 20 mL of 10% TCA. The blended solution was filtered (Whatman No. 40) and 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 an Amberlite CG-50 resin column (100~200 mesh, ϕ 8 mm×55 mm) and followed by 80 mL of 0.2 N acetic acid buffer solution. The histamine absorbed to resin was drained out by adding 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 (0.9% sulfanilic acid and 5% $NaNO_3$ were mixed as 1 : 1 in ice water, and the solution was used after 20~30 min) 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 634 S, Australia) at 510 nm and compared with the blank which was prepared with 2 mL of distilled water instead of 2 mL of the drained solution and the histamine content (mg/100 g) calculated by standard curve.

Analysis of water activity, pH, viable cell count and color value

Water activity (A_w) was determined by 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 a pH meter (pH/ion meter DP-880, Dongwoo Medical System, Korea).

Viable cell count was determined by the method of Collins and Lyne (16). Samples for measuring color value, such as L, a, b, and ΔE-value, were cut into pieces (3×3×0.4 cm^3) and the values determined by using a color difference meter (Minolta, CM-3500d, Tokyo, Japan).

Sensory evaluation

Sensory evaluation was performed by 9 sensory panels chosen from CNU graduate students who trained for over 6 months. The scoring method with 9 hedonic scale (1: dis-

like 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 raw and seasoned-dried products during storage are shown in Table 2. The moisture content of raw sample was 56.5%, but those of seasoned-dried products including C, T1 and T2 were 19.0~20.6% ranges after drying. The moisture contents of all products slightly decreased with increasing storage period because of evaporation of moisture contained in products through packaging film (9). The lipid contents in 3 products after drying decreased to 34.8~37.0% from 56.8% of raw sample on the dry basis. A crude lipid content of 19.8~22.0% range in raw sample was drained on processing of hot-air drying. However, these contents were still 2.3~2.5 times higher than those of seasoned-dried products produced with domestic Pacific saury (12). The contents of total sugar in C, T1 and T2 were 12.5~13.4%, 13.4~14.3% and 13.0~13.9% ranges, respectively. The contents of crude ash in C, T1 and T2 were 4.2~4.5%, 4.3~5.0% and 4.1~5.0% range, respectively, and shown no significant difference with increasing storage period.

Changes of histamine contents during storage

The changes of histamine contents in raw sample and seasoned-dried products (C, T1 and T2) are shown in Table 3. The histamine contents in raw fish and samples after washing and seasoning were 1.18 mg/100 g, 1.07 mg/100 g and 1.03 mg/100 g, respectively. The decrease of histamine contents after washing might be due to the draining of soluble histamine in the course of washing (17). The histamine contents of 3 seasoned-dried products were 9.08~12.08 mg/100 g range and increased with increasing storage period, but no significant differences were among the products during storage. Moreover, the histamine contents in 3 products were extremely low compared to tolerance limit of intake (100 mg/100 g) (18). Therefore, the seasoned-dried products could be safe from food poisoning.

Changes of water activity (A_w) during storage

The changes of A_w during storage in seasoned-dried Pacific saury are shown in Fig. 2. The A_w of raw fish was 0.975, and those of 3 seasoned-dried products were 0.698~0.755 range and slowly decreased with increasing storage period. This trend is thought by the decrease of moisture content (Table 2) in samples during storage. On the other hand, this range of seasoned-dried products is generally known as a A_w range of intermediate moisture food (1).

Changes of viable cell count during storage

The changes of viable cell counts in seasoned-dried Pacific saury during storage are shown in Fig. 3. The viable cell counts of C increased up to 3.7×10^7 CFU/g in 30 storage days and decreased to 45 days and then increased up to 6.8×10^7 CFU/g rapidly with increasing storage period, while those of T1 and T2 decreased up to 1.9×10^7~2.0×10^7 CFU/g range in 30 storage days and then increased up to 3.4×10^7~3.7×10^7 CFU/g range in 80 days. These changes

Table 2. Changes of proximate compositions of raw and seasoned-dried Pacific saury (imported product) during storage[1] (g/100 g)

	Raw material	C[2]			T1			T2		
		0 day[3]	45 days	80 days	0 day	45 days	80 days	0 day	45 days	80 days
Moisture	56.5±0.0	19.2±0.1	19.2±0.1	19.1±0.1	20.6±0.1	19.3±0.1	19.4±0.1	19.2±0.1	19.5±0.1	19.0±0.1
Crude protein	16.4±0.1	33.3±0.1	34.4±0.0	34.6±0.1	31.4±0.0	33.2±0.0	33.6±0.1	32.8±0.1	32.4±0.0	33.4±0.1
Crude lipid	24.7±0.1	29.4±0.1	28.1±0.1	28.4±0.1	28.4±0.1	28.7±0.1	28.5±0.1	29.1±0.1	28.6±0.1	30.0±0.1
Total sugar		13.3±0.0	12.5±0.1	13.4±0.1	14.0±0.0	14.3±0.3	13.4±0.3	13.9±0.1	13.8±0.3	13.0±0.2
Crude ash	2.0±0.1	4.2±0.0	4.5±0.0	4.2±0.0	5.0±0.0	4.3±0.1	4.7±0.0	4.6±0.0	5.0±0.1	4.1±0.0

[1]Mean value±SD (n = 3).
[2]Refer to comment in Fig. 1.
[3]Storage period.

Table 3. Changes of histamine contents in seasoned-dried Pacific saury (imported product) during storage[1] (mg/100 g)

Storage days	Raw material	After washing	After seasoning	C[2]	T1	T2
0	1.18±0.03	1.07±0.07	1.03±0.02	9.08±0.21	11.92±0.28	12.08±0.09
45				14.54±0.30	15.90±0.09	14.72±0.07
80				19.48±0.13	21.15±0.12	20.19±0.06

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

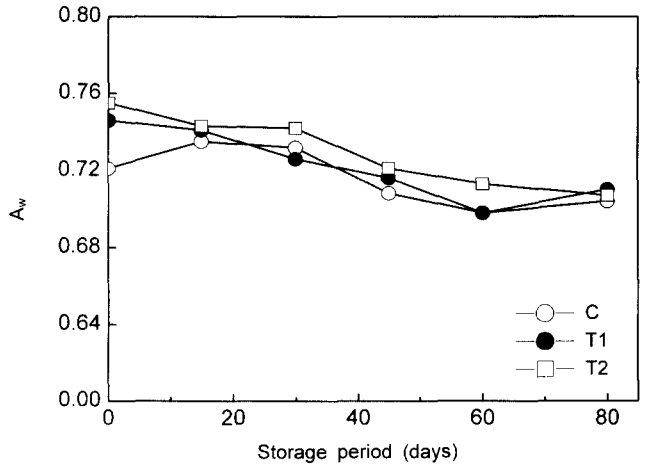

Fig. 2. Changes of water activity (A_w) in seasoned-dried Pacific saury (imported product) during storage. C : seasoning only and dried. T1 : seasoning with 0.05% BHT and dried. T2 : seasoning and treatment of liquid smoking (10 sec in 5% of smoking solution) during drying.

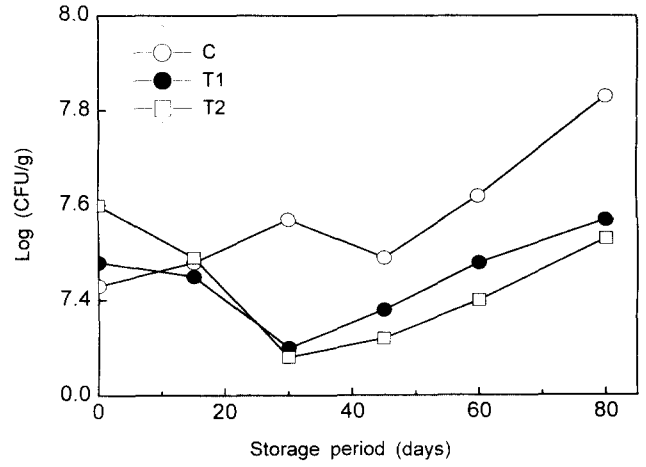

Fig. 3. Changes of viable cell counts in seasoned-dried Pacific saury (imported product) during storage. Legend refer to comment in Fig. 2.

were considered that at the initial stage, the decrease in the number of microbes might be caused by packaging following the shortage of air, but with passing time, the number of microbes increased by their adjustment to the environment. It is considered that the increase in microorganisms might be due to the increased growth on the surface of the dried products as a result of air packaging, although the products were made at the range of A_w in which microorganism could not grow. Meanwhile, the viable cell count of T2 treated by liquid smoke was lower than those of C and T1 during storage.

Changes of color values during storage

The changes of color values in seasoned-dried products during storage are shown in Table 4. The color values of T1 and T2 were not significantly different, but in 80 storage days, ΔE-value of C was simultaneously higher than those of T1 and T2. This is considered that a- and b-values of C during storage significantly increased ($p<0.05$), and finally affected to high ΔE-value of C. Lee et al. (7) also reported that a- and b-values of vacuum packed and seasoned-dried sardine products increased with increasing storage period.

Changes of sensory evaluation during storage

The results of sensory evaluation for odor, taste and overall acceptance in seasoned-dried products during storage are shown in Table 5. In the case of odor, T2 treated with liquid smoke had a significantly better odor compared to C and T1, and this might be that the treatment of liquid smoke was more preferable to panels; T2 had a higher sensory score as 7.11 even after 60 storage days, while C and T1 had 4.22 and 5.56 scores, respectively. In the taste and overall acceptance, with increasing storage period, both T1 and T2 slightly decreased, but not significantly. Especially, T2 in taste and overall acceptance showed a score of over 5.0 after 60 storage days, while C scored under 5.0 in taste after only 45 storage days, so sensory quality of C was highly declined. However, it was hard to intake C and T1 products

Table 4. Changes of color values in seasoned-dried Pacific saury (imported product) during storage[1)]

Storage days	L			a			b			ΔE		
	C[2)]	T1	T2	C	T1	T2	C	T1	T2	C	T1	T2
0	$^{c3)}22.78^{a4)}$	$^{A}22.21^{a}$	$^{E}21.29^{a}$	$^{CD}1.14^{b}$	$^{BC}1.78^{a}$	$^{A}1.30^{b}$	$^{D}1.22^{b}$	$^{BC}1.84^{a}$	$^{AB}2.18^{a}$	$^{B}74.04^{a}$	$^{A}74.63^{a}$	$^{A}75.55^{a}$
15	$^{BC}23.58^{a}$	$^{A}23.53^{a}$	$^{D}22.41^{b}$	$^{D}0.95^{a}$	$^{B}0.87^{a}$	$^{B}0.89^{a}$	$^{C}1.99^{a}$	$^{C}1.47^{a}$	$^{AB}1.80^{a}$	$^{BC}73.18^{b}$	$^{B}73.22^{b}$	$^{BC}74.34^{a}$
30	$^{C}22.68^{a}$	$^{A}23.03^{a}$	$^{CD}22.68^{a}$	$^{AB}2.20^{a}$	$^{AB}2.16^{a}$	$^{AB}1.04^{b}$	$^{BC}2.70^{a}$	$^{AB}2.25^{a}$	$^{AB}2.03^{a}$	$^{B}74.20^{a}$	$^{AB}73.83^{a}$	$^{CD}74.13^{a}$
45	$^{AB}24.51^{a}$	$^{B}23.74^{b}$	$^{BC}23.22^{b}$	$^{BC}1.65^{b}$	$^{A}2.45^{a}$	$^{A}1.25^{b}$	$^{BC}3.13^{a}$	$^{A}2.47^{b}$	$^{AB}1.90^{c}$	$^{C}72.35^{b}$	$^{B}73.12^{ab}$	$^{D}73.58^{a}$
60	$^{AB}24.27^{a}$	$^{A}23.80^{a}$	$^{A}24.47^{a}$	$^{C}1.55^{a}$	$^{C}1.46^{a}$	$^{A}1.36^{a}$	$^{AB}3.33^{a}$	$^{A}2.46^{b}$	$^{A}2.44^{b}$	$^{C}72.60^{a}$	$^{B}73.03^{a}$	$^{E}72.36^{a}$
80	$^{A}25.17^{a}$	$^{B}24.28^{b}$	$^{B}23.78^{b}$	$^{A}2.53^{a}$	$^{C}1.34^{b}$	$^{AB}1.15^{b}$	$^{A}4.21^{a}$	$^{ABC}1.98^{b}$	$^{B}1.64^{b}$	$^{A}79.76^{a}$	$^{A}74.49^{b}$	$^{AB}74.49^{b}$

[1)]L: Measures lightness and varies from 100 for perfect white to zero black (Standard plate: 97.08).
a: Measures redness when plus and greenness when minus (Standard plate: -0.17).
b: Measures yellowness when plus and blueness when minus (Standard plate: -0.27).
ΔE: $\sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$
[2)]Refer to comment in Fig. 1.
[3)]Means with the same letter in column of each sample in each item are not significantly different with increasing storage period ($p<0.05$).
[4)]Means with the same letter in each row among samples in each item are not significantly different ($p<0.05$).

Table 5. Changes of sensory evaluation in seasoned-dried Pacific saury (imported product) during storage[1)]

Storage days	Odor			Taste			Overall acceptance		
	C[2)]	T1	T2	C	T1	T2	C	T1	T2
0	$^{A3)}6.33^{b4)}$	$^{B}5.33^{c}$	$^{AB}7.44^{a}$	$^{A}6.11^{b}$	$^{B}5.33^{c}$	$^{AB}7.22^{a}$	$^{AB}5.89^{b}$	$^{B}5.56^{b}$	$^{AB}7.22^{a}$
15	$^{A}6.44^{b}$	$^{A}6.33^{b}$	$^{AB}7.44^{a}$	$^{A}6.67^{b}$	$^{A}6.44^{b}$	$^{A}7.78^{a}$	$^{A}6.44^{b}$	$^{A}6.44^{b}$	$^{A}7.78^{a}$
30	$^{AB}5.78^{b}$	$^{AB}5.78^{b}$	$^{A}7.56^{a}$	$^{B}4.22^{b}$	$^{A}6.00^{a}$	$^{BC}6.22^{a}$	$^{BC}5.33^{b}$	$^{B}5.44^{b}$	$^{BC}6.56^{a}$
45	$^{B}5.11^{b}$	$^{AB}5.44^{b}$	$^{B}6.67^{a}$	$^{B}4.67^{b}$	$^{B}5.67^{a}$	$^{C}5.56^{a}$	$^{C}5.00^{b}$	$^{B}5.22^{b}$	$^{D}5.78^{a}$
60	$^{C}4.22^{c}$	$^{AB}5.56^{b}$	$^{AB}7.11^{a}$			$^{BC}5.78$			$^{C}6.33$

[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.
[3)]Means with the same letter in column of each sample in each item are not significantly different with increasing storage period ($p<0.05$).
[4)]Means with the same letter in each row among samples in each item are not significantly different ($p<0.05$).

after 45 storage days because they smelled of off- and rancid flavors, while T2 did not smell of off-flavors until after 60 storage days. Nevertheless, T2 was too tough to intake in terms of texture. In addition, with microbial growth during storage, it was hard to intake T2 product after 60 storage 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, further studies should be undertaken to improve sensory texture by optimal drying and to inhibit microbial growth by vacuum packaging in aspects of shelf-life extending of seasoned-dried products.

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