J. Food Sci. Nutr.
Vol. 6, No. 4, p. 201~205 (2001)

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

Yong-Jun Cha†, Sung-Young Park*, Hun Kim, Eun-Jeong Jeong, Yeon-Jung Chung and Jin-Soo Kim**

Department of Food and Nutrition, Changwon National University, Changwon 641-773, Korea
**Mong-Go Foods Co., LTD., Changwon 641-765, Korea*
***Division of Marine Bioscience, and Institute of Marine Industry, Gyeongsang National University, Tongyeong 650-160, Korea*

Abstract

As a series of studies on improving the processing suitability of imported Pacific saury, oxidative stability of seasoned-dried Pacific saury treated with liquid smoke (T2 product) was examined during storage, comparing with control (C, seasoning only) and T1 (treatment of 0.05% BHT instead of liquid smoke). The pH of T2 treated with liquid smoke was relatively lower than those of C and T1 during storage. The contents of volatile basic nitrogen in all products increased continuously during storage. In the changes of TBA and POV of products during storage, the POV of T2 was lower than that of T1, and the TBA values of T1 and T2 were lower than that of C product. The major fatty acids were 22 : 1n-11, 20 : 1n-11, 16 : 0, 14 : 0, 22 : 6n-3, 20 : 5n-3, 18 : 4n-3, 16 : 1n-7, 14 : 1n-7 and 18 : 1n-9 in the both C and T2 products. The contents of polyunsaturated fatty acids in both C and T2 somewhat decreased with increasing storage period, while those of saturated and monounsaturated fatty acids increased.

Key words: smoked and seasoned-dried fish, imported Pacific saury, liquid smoke, oxidative stability, fatty acids

INTRODUCTION

Though dark fleshed fishes such as Pacific saury, mackerel and horse mackerel have excellent nutritional value, suitable processing for these fatty fishes has been limited mainly to salted-dried and/or canned products because of their high lipid contents and unstable fish protein (1). A lot of research has been performed to develop suitable processing of dark fleshed fishes as such jelly meat processing including surimi (2,3), and cold-osmotic pressure dehydration technique (4) and liquid smoking technique (5). Among these methods, a simple liquid smoking method has been used as a means of preservation and flavoring for a long time (6). Several studies about the application of liquid smoke were attempted to enhance storage stability of seafoods including sardine (5), file fish (7) and sea mussel (8), but these applications have not been available to the seafood industry until recently. Therefore, more research on the role of liquid smoke in smoked fatty fishes is needed if suitable products using fatty fishes are to be developed successfully. Among dark fleshed fishes, especially, domestic and imported Pacific saury are known to be unsuitable for processing because of its weak tissue and high lipid content, respectively (9). Nevertheless, we studied storage stability as well as suitable processing conditions of smoked and seasoned-dried products using domestic Pacific saury (10,11). We also applied these techniques to imported Pacific saury for processing of smoked and seasoned-dried products in a previous paper (9).

The objectives of this study are to examine oxidative stability of seasoned-dried Pacific saury (imported product) with treatment of liquid smoke as a series of studies on improving processing suitability of imported Pacific saury.

MATERIALS AND METHODS

Materials

Imported 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). The liquid smoke used was Scansmoke PB 2110 (P. Broste A/S, Denmark), which was donated from a product company and stored in a refrigerator (-3±1°C) until use.

The seasoning ingredients such as sugar, salt (Saean Trading Co.), MSG, Sorbitol (Samyang Genex Co.) were purchased from a local market in Changwon, Korea.

Processing of seasoned-dried Pacific saury

The standardized ratios of ingredients for seasoning of Pacific saury were 12.21 of sugar, 1.74 of salt, 1.03 of MSG, 3.02 of sorbitol in proportion to 100 of fillet of imported Pacific saury. The processing of seasoned-dried Pacific saury are followed by the same methods described in previous paper (9). Here, the washed and drained fillets were divided

†Corresponding author. E-mail: yjcha@sarim.changwon.ac.kr
Phone: 82-55-279-7485, Fax: 82-55-281-7480

into 3 portions; the control (C) was blended with seasoning (2 hr at 5°C) only and dried in a hot-air dryer (Dongyang Scientific Co. Ltd, Korea) for 40 hr at 40°C. The T2 was treated with liquid smoking (soaking for 10 sec in 5% (v/v) Scansmoke PB 2110 solution) during drying (after 26 hr), and seasoned as for the control. The third portion (Treatment 1; T1) was blended with seasoning including 0.05% BHT (w/w) before drying. The three products after drying 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 pH and volatile basic nitrogen (VBN)

Five g of sample was homogenized in a mortar with 50 mL of distilled water for 10 min and the pH was determined using a pH meter (pH/ion meter DP-880, Dongwoo Medical System, Korea).

The content of VBN was determined by Conway microdiffusion method (12).

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

Total lipid extraction was followed using the Bligh and Dyer method (13). The POV and TBA were determined by the A.O.C.S. method (14) and steam distillation method (15), respectively. TBA value was quantitatively expressed by thiobarbituric acid reactive substances (TBARS).

Analysis of fatty acid compositions

Fatty acid composition was determined by a method of Suzuki et al. (16) 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. The oven temperature was programmed at 180°C initially (10 min hold), then increased to 230°C at 3°C/min (15 min hold). Injection port and detector (FID) temperatures were set at 250°C, respectively. Quantification of each fatty acid regarded a united peak of retention time in chromatogram of sample was expressed as area percent to total area percent.

RESULTS AND DISCUSSION

Changes of pH and volatile basic nitrogen (VBN) contents during storage

The changes of pH in seasoned-dried Pacific saury (imported product) during storage are shown in Fig. 1. The pHs of C and T1 during storage were 6.19~6.34 range, while pH of T2 was 6.12~6.23 range and relatively lower than those of C and T1. The low pH of T2 might be caused by acid and phenol components in liquid smoke treated during seasoning (17,18). However, the pH of all products did not show significant changes during storage. These trends were similar to the results of Park et al. (19).

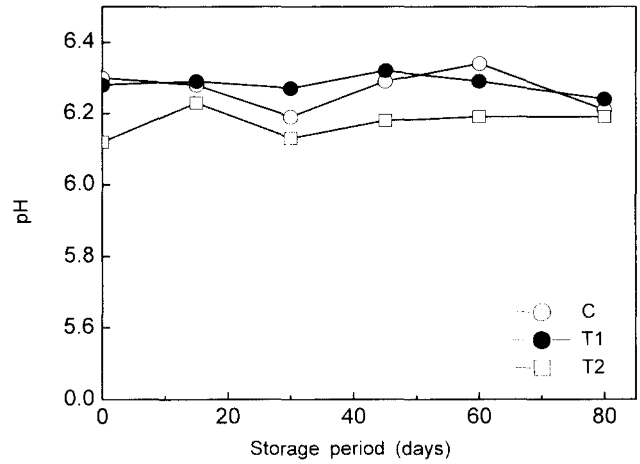

Fig. 1. Changes of pH in seasoned-dried Pacific Saury (imported product) during storage. C: seasoning only and dried. T1: seasoning with 0.05% BHT and dried. T2: seasoning and treatment of liquid smoking (10 sec in 5% of smoking solution) during drying.

During storage, the changes of VBN contents in seasoned-dried products are shown in Fig. 2. The VBN content of raw sample was 8.16 mg/100 g (no data). The VBN contents of 3 seasoned-dried products slightly increased with increasing of storage period, but those of C increased sharply from 30 storage days (42.69 mg/100 g) to 45 days (51.94 mg/100 g). This increase of VBN contents in all products with increasing storage period seem to be caused by the generation of trimethylamine (20) and ammonia or amines (1). Among the three products, with increasing storage period, the VBN content of T2 was lower than those of C and T1, and this trend was similar to the results in seasoned-dried products processed with domestic Pacific saury (11) and in seasoned-dried sardine (5).

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

The changes of TBA and POV contents in seasoned-dried

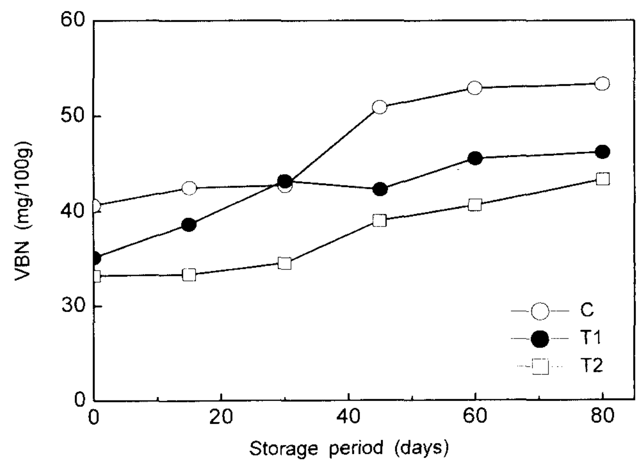

Fig. 2. Changes of volatile basic nitrogen (VBN) in seasoned-dried Pacific saury (imported product) during storage. Legend refer to comment in Fig. 1.

products during storage were shown in Fig. 3 and Fig. 4, respectively. The TBA values of all products rapidly increased up to 15 storage days and then decreased continuously, and maximum of TBA values of C, T1 and T2 in 15 days were 36.18 mg/kg, 20.97 mg/kg and 19.27 mg/kg, respectively. The results of this study showed similar trends with seasoned-dried products of domestic Pacific saury (11). Laleye et al. (21) and Gokalp et al. (22) reported that abundant malonaldehyde, which reacts with thiobarbituric acid (TBA), is generated in the initial step of storage, but TBA values during long-term storage decreased because malonaldehyde is so reactive and easily reacts with carbonyl compounds, amino acids and urea. Since, as shown, the content of T2 was lower than those of T1 and C, the antioxidative effect of liquid smoke was considered when applied to seasoned-dried products.

In the change of POV in seasoned-dried products, they increased with increasing storage period, and the POV of C (49.25 meq/kg) in 0 day increased up to 135.23 meq/kg of maximum in 60 storage days and then somewhat decreased in 80 storage days, while those of T1 (13.09~57.63 meq/kg) and T2 (11.00~62.12 meq/kg) slowly increased but extremely lower than that of C. In previous studies on liquid smoke applied to seafoods, Lee et al. (23), Lee et al. (5) and Hollenbeck (24) reported that the lower POV in the products treated with liquid smoke is due to inhibition effect for lipid oxidation by phenol and its derivatives contained in liquid smoke. On the other hand, Takiguchi (25) reported that lipid oxidation in fish having high lipid contents is faster because a great quantity of accumulated lipid is contained under the skin tissue, but that in fish having lower lipid content is difficult because lipid is accumulated in the deep tissue. Therefore, when seasoned-dried products are made using imported and domestic Pacific saury, the imported product was sensitive to lipid oxidation due to its high lipid content (28.1~30.0%) (10), compared with 11.9~13.6% of domestic products (11).

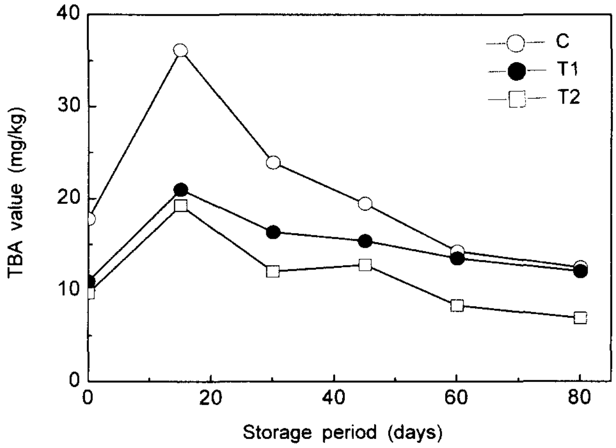

Fig. 3. Changes of thiobarbituric acid (TBA) value in seasoned-dried Pacific saury (imported product) during storage. Legend refer to comment in Fig. 1.

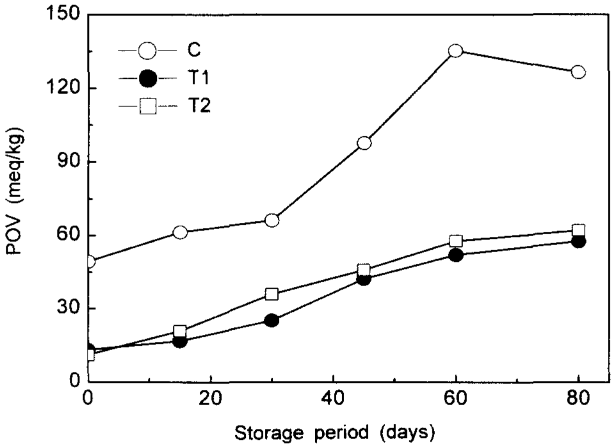

Fig. 4. Changes of peroxide value (POV) in seasoned-dried Pacific saury (imported product) during storage. Legend refer to comment in Fig. 1.

Changes of fatty acid compositions during storage

The composition of total fatty acids of seasoned-dried Pacific saury during storage are shown in Table 1. In both C and T2 samples, the major fatty acids were 22 : 1n-11, 20 : 1n-11, 16 : 0, 14 : 0, 22 : 6n-3, 20 : 5n-3, 18 : 4n-3, 16 : 1n-7, 14 : 1n-7 and 18 : 1n-9 in order. Lee et al. (26) and Jeong et al. (27) reported that the main fatty acids in the 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 trend with this study. However, the contents of PUFA of imported Pacific saury products in this study were lower than those of domestic products (11).

The contents of monounsaturated fatty acids (MUFA) (45.1~51.5% range) were the highest in the total fatty acids of both C and T2 products, and PUFA (28.3~34.4% range) and saturates (20.5~23.4% range) were followed in order. The contents of 14 : 0 (7.1~7.8% range) and 16 : 0 (7.7~10.7% range) in saturated fatty acids (SFA) 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 (11.7~13.7% range) was the highest, and 20 : 1n-11 (7.1~10.6% range), 16 : 1n-7 (2.9~5.0% range) and 14 : 1n-7 (2.9~4.5% range) were followed in order, and the contents of MUFA as well as SFA in C and T2 somewhat increased after 60 days of storage. The contents of ω-3 series such as 22 : 6 (5.8~8.3% range), 20 : 5 (4.4~6.0% range) and 18 : 4 (5.1~5.8% range) in the PUFA were higher than those of the others, and the contents of PUFA in both C and T2 somewhat decreased with increasing storage period. Whereas increase in SFA and MUFA, decrease trend in PUFA during storage is considered as its unstable double bonds. However, the difference in contents between C and T2 during storage was not significant. These results in this study were similar with reports on boiled-dried anchovy (28) and on dried conger eel (29).

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

Fatty acids	C[1]		T2	
	15 days	60 days	15 days	60 days
14 : 0	7.1	7.7	7.8	7.5
15 : 0 iso	0.4	0.4	0.4	0.4
15 : 0	0.6	0.6	0.7	0.7
16 : 0 iso	trace	0.1	trace	0.1
16 : 0	7.7	10.7	8.3	10.7
17 : 0 iso	1.3	1.5	1.6	0.3
17 : 0	0.2	0.4	0.2	0.4
18 : 0	1.3	1.4	1.1	1.5
20 : 0	0.4	0.1	0.4	0.3
22 : 0	1.5	0.3	1.3	0.4
Saturates	20.5	23.4	21.9	22.2
14 : 1n-7	3.3	3.7	2.9	4.5
15 : 1n-8	0.2	0.3	0.4	0.3
16 : 1n-9	2.7	3.6	2.9	4.3
16 : 1n-7	4.4	5.0	2.9	4.6
16 : 1n-5	0.4	0.3	0.2	0.3
17 : 1n-10	0.6	0.6	0.7	0.5
17 : 1n-8	0.2	0.3	0.2	0.1
18 : 1n-9	2.9	3.5	2.7	4.2
18 : 1n-7	0.8	0.9	0.7	1.1
18 : 1n-5	1.3	0.6	0.7	0.1
20 : 1n-11	7.1	10.6	9.2	9.2
20 : 1n-9	1.7	1.7	2.5	2.6
20 : 1n-7	0.6	0.3	1.1	0.4
22 : 1n-11	12.7	11.7	13.4	13.7
22 : 1n-9	1.9	1.5	1.6	1.2
22 : 1n-7	1.9	0.4	1.6	0.8
24 : 1n-7	2.3	3.4	2.9	3.4
Monoenes	45.1	48.4	46.4	51.5
18 : 2n-9	2.9	1.7	1.8	0.4
18 : 2n-6	2.3	1.5	1.8	1.6
18 : 3n-4	2.3	1.0	0.9	0.5
18 : 3n-3	1.9	1.5	1.8	1.6
18 : 4n-3	5.6	5.4	5.8	5.1
20 : 2n-6	trace	1.0	trace	0.5
20 : 3n-3	1.5	0.1	1.3	0.4
20 : 4n-6	2.7	0.5	2.5	1.1
20 : 4n-3	2.3	0.9	2.0	1.5
20 : 5n-3	5.4	4.9	6.0	4.4
21 : 5n-3	1.0	0.5	1.8	1.5
22 : 5n-6	0.2	0.1	0.7	1.1
22 : 5n-3	0.4	0.9	1.1	1.6
22 : 6n-3	5.8	8.0	6.7	8.3
Polyenes	34.4	28.3	34.2	29.4

[1]Refer to comment in Fig. 1.

REFERENCES

1. Park, Y.H., Chang, D.S. and Kim, S.B. : *Sea Food Processing and Utilization.* Hyungseul Press, Seoul, p.1128 (1994)
2. Ishikawa, S., Nakamura, K., Funji, Y., Yamano, G., Sugiyama, T., Shinozaki, K., Tobisa, K. and Yamaguchi. : Fish jelly product (kamaboko) and frozen minced meat (frozen surimi) made of sardine-III. Influences of the treatment methods formaterials just after catch on the kamaboko forming ability of sardine meat. *Bull. Tokai Reg. Fish. Res. Lab.*, **99**, 31 (1979)
3. Kurokawa, T. : Quality of commercial frozen surimi of sardine. *Nippon Shokuhin Kogyo Gakkaishi*, **29**, 48 (1982)
4. Lee, J.S., Joo, D.S., Kim, J.S., Cho, S.Y. and Lee, E.H. : Processing of a good quality salted semi-dried mackerel by high osmotic pressure resin dehydration under cold condition. *Korean J. Food Sci. Technol.*, **25**, 468 (1993)
5. Lee, E.H., Kim, J.S., Kim, H.H., Lee, J.K., Oh, K.S. and Kwon, C.S. : Preparation and keeping quality of vacuum packed seasoned dried sardine. *Bull. Korean Fish. Soc.*, **19**, 52 (1986)
6. Sink, J.D. : Effects of smoke processing on muscle food product characteristics. *Food Technol.*, **33**, 72 (1979)
7. Lee, E.H., Ohshima, T., Wada, S. and Koizumi, C. : Preparation and keeping quality of vacuum-packed and seasoned-dried filefish products. *Bull. Korean Fish. Soc.*, **15**, 99 (1982)
8. Lee, E.H., Chung, S.Y., Koo, J.G., Kwon, C.S. and Oh, K.S. : Studies on processing and keeping quality of retort pouched foods. (1) Preparation and keeping quality of retort pouched seasoned dried sea mussel products. *Bull. Korean Fish. Soc.*, **16**, 355 (1983)
9. Cha, Y.J., Park, S.Y., Cho, W.J., Lee, Y.M., Kim, H.J. and Kim, J.S. : Storage stability of seasoned-dried Pacific saury (imported product) treated with liquid smoke. *J. Food Sci. Nutr.*, **6**, 235 (2001)
10. Cha, Y.J., Park, S.Y., Jeong, E.J., Chung, Y.J. and Kim, S.J. : Quality properties of seasoned-dried Pacific saury treated with liquid smoke. 2. Processing conditions for seasoned-dried Pacific saury treated with liquid smoke. *J. Fish. Sci. Tech.*, **4**, (in press) (2001)
11. Park, S.Y., Chung, Y.J., Lee, Y.M., Yoon, S.S. and Cha, Y.J. : 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. *J. Fish. Sci. Tech.*, (in press) (2001)
12. Ministry of Social Welfare of Japan : Guide to experiment of sanitary inspection. 1. Volatile basic nitrogen., Japan, p.30 (1960)
13. Bligh, E.G. and Dyer, W.J. : A rapid method of total lipid extraction and purification. *J. Biochem Physiol.*, **37**, 11 (1959)
14. AOCS : *Official Methods and Recommended Practices of the American Oil Chemists Society.* 4th ed., American Oil Chemists' Society, Champaign, IL, USA (1990)
15. Tarladgis, B.G., Watts, B.M. and Younathan, M.T. : A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Am. Oil Chem. Soc.*, **37**, 44 (1960)
16. Suzuki, H., Wada, S., Hayakawa, S. and Tamura, S. : Effects of oxygen absorber and temperature on $\omega 3$ polyunsaturated fatty acids of sardine oil during storage. *J. Food Sci.*, **50**, 358 (1985)
17. Sink, J.D. and Hsu, L.A. : Chemical effects of smoke processing on frankfurter manufacture and storage characteristics. *J. Food Sci.*, **42**, 1489 (1977)
18. Park, S.Y., Kim, H., Cho, W.J., Lee, Y.M., Lee, J.S. and Cha, Y.J. : Quality properties of seasoned-dried Pacific saury treated with liquid smoke. 1. Volatile flavor compounds in commercial liquid smokes. *J. Fish. Sci. Tech.*, **4**, (in press) (2001)
19. Park, C.K., Yun, H.Y., Suh, S.B., Lee, E.H. and Yoo, Y.C. : Studies on the processing and preservation of seasoned smoked fish. *Bull. Fish. Res. Dev. Agency.*, **37**, 85 (1986)
20. Zama, K. : Oxidation of phospholipids of aquatic animals. *Bull. Japan. Soc. Sci. Fish.*, **36**, 826 (1970)
21. Laleye, C.L., Simard, R.E., Lee, B.H. and Holley, R.A. : Shelf-life vacuum of nitrogenpacked pastrami, effects of packaging atmospheres temperature and duration of storage on microflora changes. *J. Food Sci.*, **49**, 827 (1984)
22. Gokalp, H.T., Olerman, H.W., Plimton, R.F. and Harper, W.J. : Fatty acid of neutral and phospholipid, rancidity scores and TBA values as influenced by packing and storage. *J. Food Sci.*, **48**, 229 (1983)
23. Lee, E.H., Kim, J.G., Cha, Y.J., Oh, K.S., Koo, J.G. and Kwon, C.S. : Studies on processing and keeping quality of retort pouched foods. (4) Preparation and keeping quality of retort pouched seasoned baby clam. *Bull. Korean Fish. Soc.*, **17**, 499 (1984)

24. Hollenbeck, C.M. : Liquid smoke flavoring status of development. *Food Tech.*, **33**, 88 (1979)
25. Takiguchi, A. : Lipid oxidation and hydrolysis in dried anchovy products during drying and storage. *Bull. Japan Soc. Sci. Fish.*, **53**, 1463 (1987)
26. Lee, E.H., Oh, K.S., Ahn, C.B., Chung, Y.H., Kim, J.S. and Jee, S.K. : Seasonal variation in lipids and fatty acid composition of sardine, *Sardinops melanosticta*. *Korean J. Food Sci. Technol.*, **18**, 245 (1986)
27. Jeong, B.Y., Choi, B.D., Moon, S.K. and Lee, J.S. : Fatty acid composition of 72 species of Korean fish. *J. Fish. Sci. Tech.*, **1**, 129 (1998)
28. Lee, E.H., Kim, J.S., Ahn, C.B., Park, H.Y., Jee, S.K., Joo, D.S., Lee, S.W., Lim, C.W. and Kim, I.H. : The effect of Taipet-F and Bactokil on retarding lipid oxidation in boiled-dried anchovy. *J. Korean Soc. Food Nutr.*, **18**, 181 (1989)
29. Suh, J.S. and Lee, K.H. : Studies in browning reaction in dried fish; Lipid oxidative browning in dried conger eel and properties of browning products. *Bull. Korean Fish. Soc.*, **27**, 454 (1994)

(Received September 22, 2001)