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Quality Changes of Canned Tuna in Cottonseed Oil during Storage

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To fulfill the requirements for establishing processes of canning low-acid foods, canned tuna packed in cottonseed oil (CTCO) sterilized at 110℃ for varying F_0-values was subjected to microbial, sensory and chemical analyses. The investigation included the long-term quality stability of those products stored at 5℃, 25℃ and 50℃ for 120 days. Longer sterilization (F_0>5.18 min) caused no remarkable changes in pH, amino nitrogen content, TBA value, POV and sensory scores of the CTCOs during storage at all experimental temperatures. But the sterilizing with $F_0 \leq 5.18$ min resulted generally poor quality in all experimental analyses. Consequently, F_0-value 6.0 min may be applicable to sterilization of CTCO for long-term storage stability.

Key words : canned tuna, cottonseed oil, F_0-value, storage stability

Introduction

Canned tuna packed in cottonseed oil (CTCO) is one of the most frequently consumed low-acid canned seafood in Korea. In the case of canned smoked-oyster, one of the most representative exporting canned seafood in Korea, it has been produced by the cannery sterilizing conditions required by foreign buyers. But the CTCOs have been produced by conventional method without any conisideration in F_0-value criterion for the process optimization for energy consumption and product quality. To determine the optimal sterilizing condition for the CTCO is, therefore, urgent problem in view point of not only nutritional quality but also energy consumption. The sterilizing process should be optimized in the consideration of the relation between the degree of energy consumption and other factors, such as microbiological safety, nutritional and sensory quality of the product (Singh, 1979; Saguy and Karel, 1979; Barreiro et al., 1984; An et al., 1992; Cho et al., 1992; Cho, 1993; Jung et al., 1994; Han et al., 1994).

In spite of the great importance of the F_0-value as a sterilizing criterion for the low-acid canned seafood, few studies dealing with the sterilizing conditions for canned seafood at Korea have been published. To solve these problems, we suggested 6.0min as F_0-value criterion for commercial sterilization of the CTCO (Han et al., 1994) and canned smoked-oyster in cottonseed oil (Han et al., 1995a). We also investigated the quality changes of the CTCO during sterilization (Jung et al., 1994) and canned smoked-oyster during storage (Han et al., 1995b). As a series study of same purpose for low-acid canned seafood, we discussed in this paper about the quality changes of the CTCOs during long-term storage with respect to the F_0-value.

Materials and Methods

Test product : The CTCO was prepared as described in the previous paper (Han et al., 1994) by con-

ventional canning method in Gosung Mulsan Co. Ltd., a canning factory in Gosung-Gun, Kyoungnam, Korea. Frozen skipjack (*Katsuwonus pelamis*) was thawed in a tank of running water, head and viscera were removed and then precooked in a steam chest at 90℃ for 65 min. The white muscle was cleaned by removal of skin, bones, and dark muscle. The meats were then held at 2℃ overnight so that the meat would cool and firm up enough to handle. The precooked tuna chunks were vacuum sealed in a cylindrical can (211×109 mm) with cottonseed oil (36 ± 1 g) and vegetable sauce (23 ± 2 g), and then stored at −40℃ until investigating.

Sterilization, F_0-value measurement and storage : The frozen CTCOs were thawed in a temperature controlled water tank for approximately 4 hours to insure the homogeneity of the tuna meat temperature and then sterilized in a vertical still-retort equipped with a lethal rate measuring system (An et al., 1992; Cho et al., 1992; Cho 1993; Han et al., 1994). The F_0-values were the integrated lethal rate measured during the whole sterilizing process in every 0.2 sec (An et al., 1992; Cho et al., 1992; Cho 1993; Han et al., 1994, 1995a, 1995b; Han and Kim, 1995). The sterilized CTCOs were then stored at 5, 25, and 50℃, and the quality changes during long-term storage were determined.

Analytical procedure : Contents of moisture, protein (N×6.25), lipid and ash were determined by the standard procedures of A.O.A.C. (1982). Contents of volatile basic nitrogen (VBN) and amino nitrogen (NH_2-N) were determined by the methods of Miwa and Iida (1973), and Spies and Chamber (1951). The thiobarbituric acid (TBA) value and peroxide value (POV) were determined by the method of Sidwell et al. (1955), and A.O.A.C. (1982), respectively. The content of brown pigment was determined by the method of Hirano et al., (1987). Counting of viable cells were carried out by the methods of A.P.H.A. (1984), Gibbs and Skinner (1966), Harrigan and MaCnee (1976), Collins and Lyne (1976) and Bergey's Manual of Systematic Bacteriology (Kreig and Holts, 1984).

Results and Discussion

Proximate composition before sterilization : Proximate composition and some values of the CTCO before and after sterilization are shown in Table 1. VBN content of the CTCO after precooking was 16.28 mg/100 g, and it was enough to guarantee the freshness of the CTCO. Concentration of viable cell of the precooked CTCO was 4.2×10^2/ml. The representative spore-forming bacteria identified were *Bacillus subtilis, B. cereus* and *B. pasteurii. B. subtilis* was the most heat resistant among them, but the spores could be sufficiently destructed by commercial sterilization with F_0-value of 6 min (Han et al., 1994).

Changes in composition during sterilization : Proximate composition and viable cell counts of the CTCO sterilized at 110℃ after incubation for 3 weeks are shown in Table 2. The concentration changes of each proximate composition were below ca. 1% and

Table 1. Proximate composition, number of viable cell, and some values of the precooked* CTCO

Moisture	57.1(%)	pH	6.11
Crude protein	23.1(%)	NH_2-N	142 (mg/100g)
Crude lipid	16.3(%)	VBN	16.3 (mg/100g)
Crude ash	3.1(%)	Viable cell counts	4.2×10^2/ml
Others	0.4(%)		

* Precooked at 90℃ for 65 min

Table 2. Proximate composition and viable cell counts of the CTCO sterilized at 110℃ after incubation at 50 ± 1℃ for 21 days (Unit : %)

F_0-value (min)	Moisture	Crude protein	Crude lipid	Crude ash	Others	Viable cell counts/ml
0	57.1	23.1	16.3	3.1	0.4	4.2×10^2
1.11	57.2	22.9	16.1	3.2	0.5	4.4×10^1
1.58	57.0	23.4	16.2	3.0	0.4	1.0×10^0
4.52	56.7	23.5	16.1	3.2	0.5	ND*
6.57	56.5	24.1	16.0	3.0	0.4	ND
8.54	56.5	24.0	16.1	3.0	0.4	ND
10.25	55.9	24.2	16.2	3.2	0.5	ND
15.43	55.9	24.2	16.4	3.1	0.4	ND
20.27	56.1	24.0	16.2	3.1	0.6	ND

* Not detected

could be neglected without any great error. The slight changes in moisture and protein concentration might be caused by the thermal coagulation and decomposition of protein. Taguchi et al. (1982) and Lee et al. (1983) recognized also the same tendency in canned tuna and retort pouched seasoned-oyster.

Sensory quality after sterilization : Sensory characteristics of the CTCO after sterilization at 110℃ are shown in Table 3. The CTCOs sterilized with $F_0<5.18$ min revealed unfavorable scores in color, taste, and odor as compared with the products sterilized with F_0-values of 5.18~10.01 min, and those sterilized with $F_0 \geq 15.43$ min resulted drastical cooking odor. Jung et al. (1994) reported that the color value and solvent soluble brown pigment density of the CTCOs rose steadily during sterilization as F_0-value increased. But the products sterilized with F_0-values of 5.18~10.01 min revealed acceptable scores of the same level in color and other sensory characteristics.

In the case of the *in vitro* protein digestibiliy of the CTCO, the digestibility increased significantly at the initial step of the thermal sterilization ($F_0=0.8$ min), but then the digestibility began to rise very slowly with extended sterilizing time i.e. F_0-value, and there were some differences in protein digestibiliy from 1 to 2% between products sterilized with different F_0-values (Jung et al., 1994). Lee et al. (1983) recognized also the same tendency in retorted pouched seasoned-oyster. But the difference in protein digestibility was enough to neglect with respect to the energy consumption caused by the excessive heating.

Table 3. Sensory scores of the CTCO after sterilization at 110℃

F_0-value (min)	Color	Taste	Odor	Overall acceptance
0	3.0^{b*}	3.5^{c}	2.6^{c}	2.8^{b}
1.44	3.4^{b}	3.7^{c}	4.1^{b}	4.4^{b}
5.18	5.9^{a}	6.2^{ab}	6.0^{a}	6.1^{a}
10.01	6.5^{a}	6.5^{a}	6.2^{a}	6.7^{a}
15.43	6.5^{a}	6.6^{a}	6.4^{a}	6.4^{a}
21.54	6.0^{a}	5.8^{b}	5.9^{a}	6.0^{a}

Numericals having same shoulder letter are not significantly different in $p<0.01$.
* a, b, ab, and c mean Dunkan's multiple range test for the F_0-values.

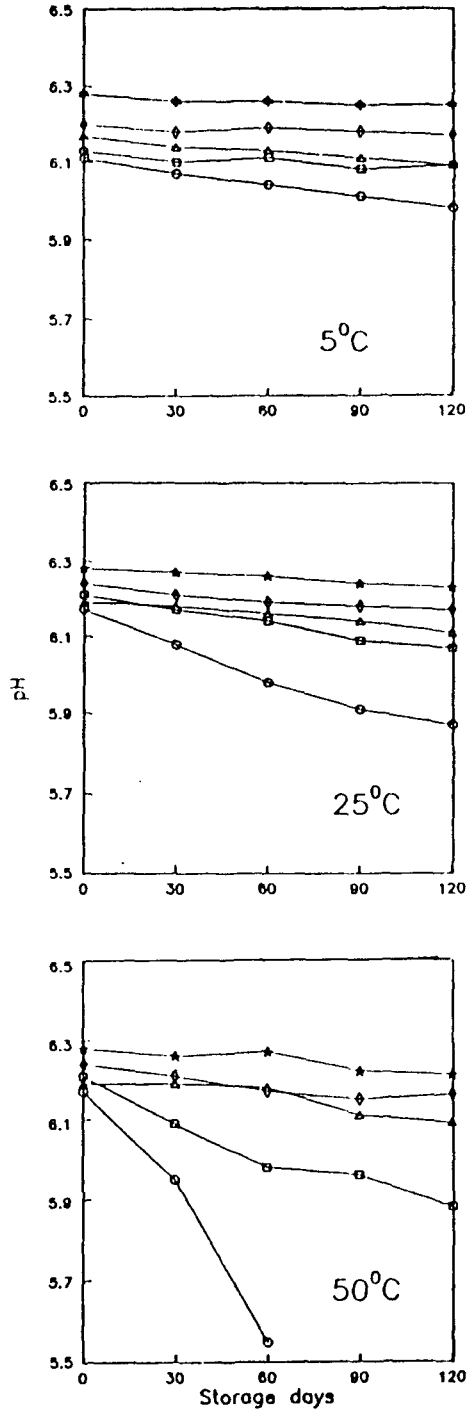

Fig. 1. Changes in pH of the CTCO during storage.
* CTCO; Canned tuna packed in cottonseed oil.
F_0-value(min); −○− : 1.44, −□− : 5.18, −△− : 10.01, −◇− : 15.43, −☆− : 21.54.

On the other hand, Heiss and Eichner (1984) suggested 2.7~7.8 min for pacific and atlantic canned tuna, and Han et al. (1994) suggested 6.0 min as a rational F_0-value for Korean CTCOs with respect to the microbiological safety.

Judging from the results in Table 3 and investigations of Heiss and Eichner (1984), Han et al. (1994) and Jung et al., (1994), it was considered that the reasonable F_0-value for the CTCO in a commercial sterilization was 6.0 min.

Quality changes during storage : Changes in pH of the CTCOs sterilized at 110℃ are shown in Fig. 1. The pH value of the product with F_0=1.44 min declined only slightly during storage at 25℃, but that of products with F_0=1.44 and 5.18 min decreased drastically at 25 and 50℃. It was considered that the pH changes of the products with F_0=1.44 and 5.18 min at higher storage temperatures might be caused by the growth of putrefactive microorganisms which could survive after insufficient sterilization such as with F_0 =1.44 and 5.18 min (Han et al., 1995b). But no remarkable changes in pH could be recognized in all products sterilized with F_0-values greater than 5.18 min.

As shown in Fig. 2, the contents of NH_2-N of the CTCOs increased slowly at all storage temperatures. The changes in products sterilized with F_0=1.44 and 5.18 min were faster than those with greater F_0-values, especially at higher storage temperatures. Taguchi et al., (1982) and Cho (1993) could also recognize same phenomena in the canned tuna meat in cottonseed oil. They suggested the thermal decomposition of proteins at higher temperatures as the reason of the changes.

Changes in contents of brown pigment extractable with 66% ethyl alcohol are shown in Fig. 3. The CTCOs retorted sufficiently revealed no remarkable changes in brown pigment content with exception of those sterilized with F_0=1.44 and 5.18 min and stored at 25 and 50℃. In previous paper, it was recognized that color value and solvent soluble brown pigment

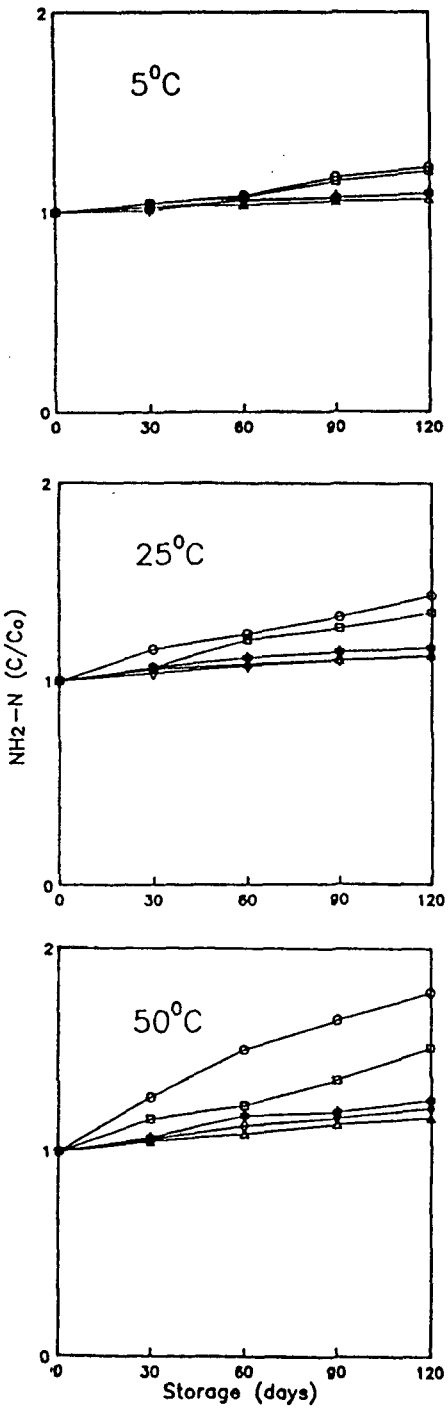

Fig. 2. Changes in NH_2-N contents of the CTCO during storage.
* CTCO; Canned tuna packed in cottonseed oil. C; Final concentration, C_o; Initial concentration. F_o-value(min); -○- : 1.44, -□- : 5.18, -△- : 10.01, -◇- : 15.43, -☆- : 21.54.

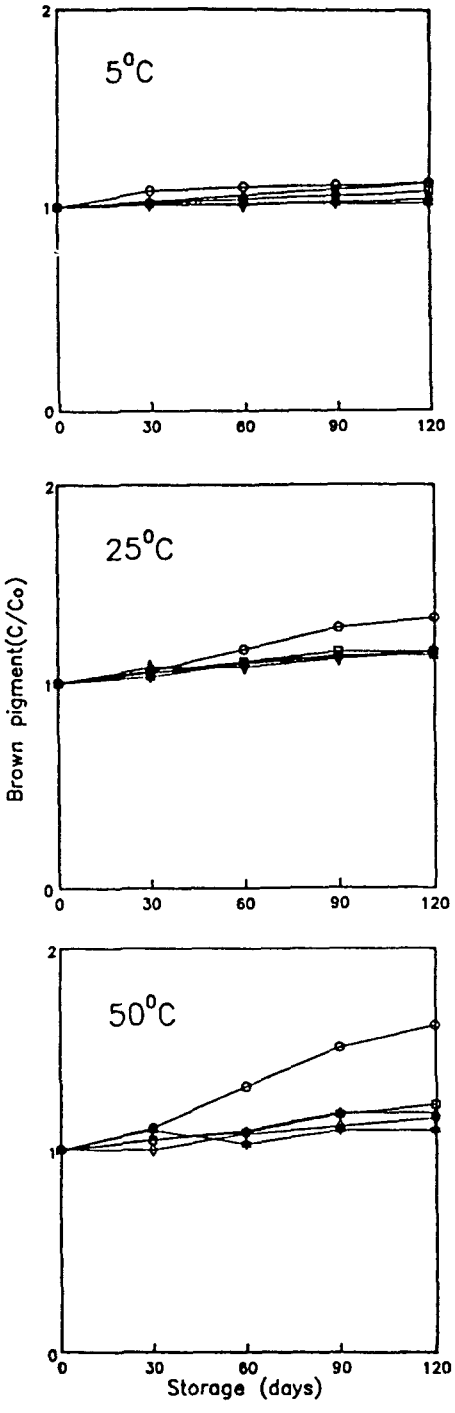

Fig. 3. Changes in brown pigment contents of the CTCO during storage.
* CTCO; Canned tuna packed in cottonseed oil. C; Final concentration, C_o; Initial concentration. F_o-value(min); -○- : 1.44, -□- : 5.18, -△- : 10.01, -◇- : 15.43, -☆- : 21.54.

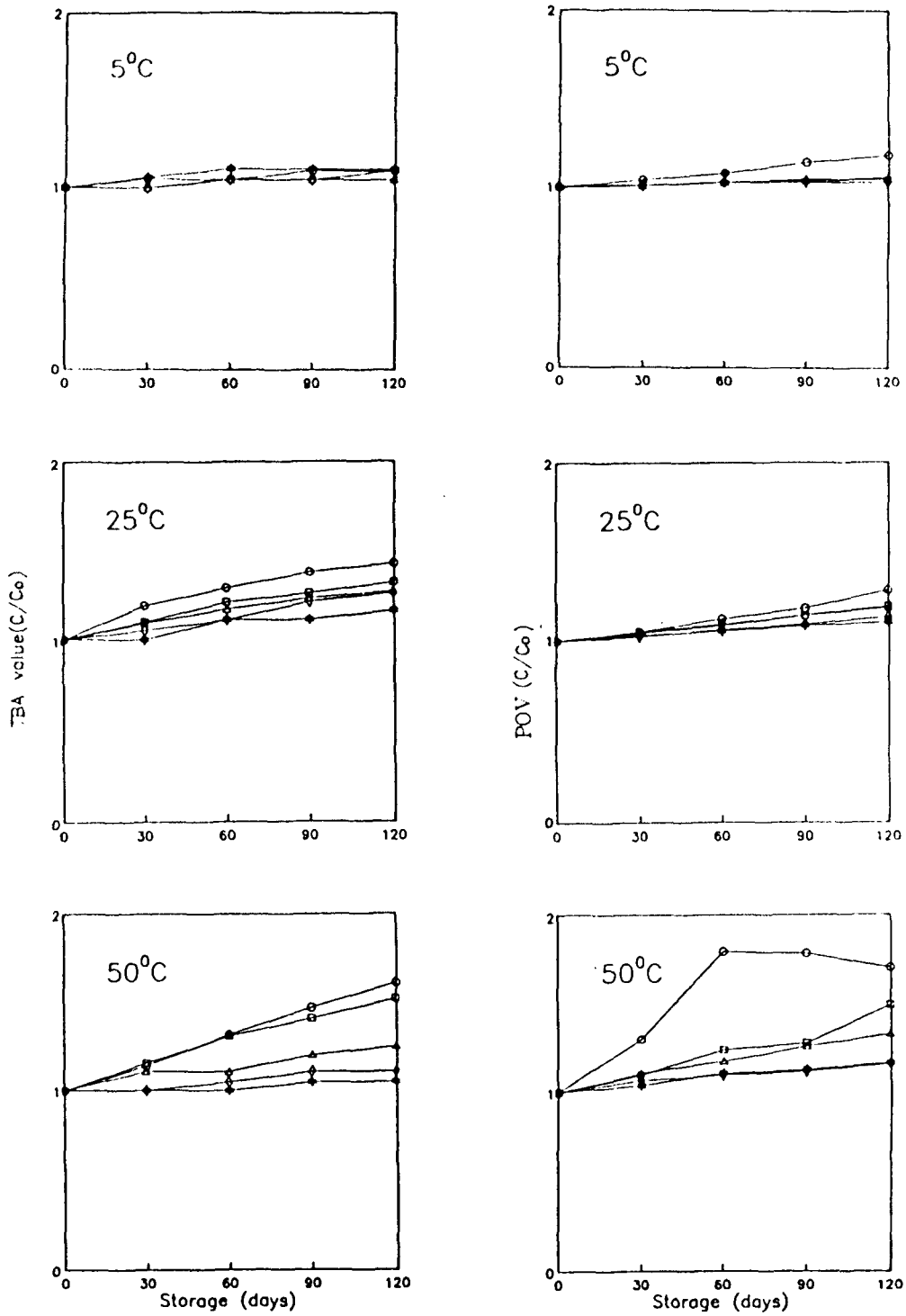

Fig. 4. Changes in TBA value and POV of the CTCO during storage.
* CTCO; Canned tuna packed in cottonseed oil.
C; Final concentration, C_0; Initial concentration.
F_0-value(min); −○− : 1.44, −□− : 5.18, −△− : 10.01, −◇− : 15.43, −☆− : 21.54.

density of the CTCOs rose steadily with increasing F_0-values at 110℃ (Jung et al., 1994). But the amount of brown pigment in sufficiently retorted CTCOs varied fast little during long-term storage at 5~50℃.

Changes in TBA value and POV of the CTCOs, the indicative value of lipid oxidation, are shown in Fig. 4. The TBA values of the products sterilized with F_0 =1.44 and 5.18 min increased slightly at higher storage temperatures. But those of the products sterilized with greater F_0-values showed no remarkable changes at 5℃, 25℃ and 50℃. It was considered that the CTCOs sterilized with F_0>5.18 min were retorted sufficiently, and most of the TBA-reactive substances were decomposed during thermal sterilization (Lee et al., 1984). Jung et al. (1994) recognized also same tendency in the canned tuna in cottonseed oil. They reported that the TBA value of constitutional tuna meat in oil declined rapidly with retorting time, but that of the added cottonseed oil increased only slightly, and the resulted TBA value change of the total oil in the canned tuna was negligible.

The changing tendency of POVs of the CTCOs during storage was almost same as that of TBA values. It has been already reported that POV reached a maximum value and then declined, and the results of those values were extremly sensitive to temperature changes (Nawar, 1985). No remarkable changes in POV were observed in the products sterilized with F_0 >5.18 min, as the case of TBA-values. Same tendency was also recognized in the canned smoked-oyster in cottonseed oil during storage by Han et al. (1995b).

Conclusion

Quality changes of the canned tuna patked in cottonseed oil (CTCO) were investigated to determine an optimal F_0-value to guarantee the microbiological safety and quality stability during long-term storage. The CTCOs were sterilized at 110℃ with various F_0-values and stored at 5, 25, and 50℃. No remarkable changes in sensory score, pH, content of NH_2-N, TBA value, and POV of the CTCOs sterilized with F_0>5.18 min were observed at all storage temperatures, while those of the products with $F_0 \leq 5.18$ min changed remarkably. Hence, it was considered that the rational F_0-value with respect to the microbiological safety and quality stability of the CTCO was 6.0 min.

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참치 기름담금 통조림의 저장중의 품질변화

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110℃에서 F_0-값을 달리하여 가열살균한 참치 기름담금 통조림을 5, 25 및 50℃에서 120일간 저장하면서, 저장중의 품질변화를 검토하였다. F_0-값 5.18분 이하의 조건으로 열처리한 통조림은 저장기간이 길어짐에 따라서 관능적 품질, pH, 아미노 질소 함량, TBA-값 및 POV가 심하게 변하였다. 그러나 F_0-값 5.18분을 초과하여 가열살균한 제품에서는 품질변화가 거의 없었다. 따라서 전보에서 이미 보고한 바와 같이 참치 기름담금 통조림의 최적 가열살균 조건은 6분으로 판단되었다.