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Establishment of F_0-value Criterion for Canned Smoked-Oyster in Cottonseed Oil

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F_0-values of canned smoked-oyster in cottonseed oil (SOCO) were measured using a microcomputer aided F_0-value measuring system, and the microbiological safety of the canned SOCO was evaluated to optimize the energy consumption. Most of the microorganisms in raw oyster were saprophytes. No microorganisms were detected from the canned SOCO which was pretreated by conventional procedure and sterilized at 110℃ with F_0-value of 5.92min and over. The most heat resistant microflora isolated from the raw oyster was Bacillus sp.. D-value at 121.1℃ and z-value of spores of *Bacillus* sp. in the SOCO homogenate were 4.10min and 10.91℃, respectively. After 120 days storage at 50℃, no growth of microorganisms was recognized from the canned SOCO with F_0-value of 5.92min.

Key words : F_0-value, canned smoked-oyster

Introduction

To determine the optimal sterilization conditions of low acidic canned seafoods is urgent problem in Korea in view point of not only nutritional food quality but also energy consumption. But still now studies on this problem were very few except the studies on process automization (An et al., 1992), F_0-value measuring system (Cho et al., 1992) and F_0-value criterion for canned tuna meat packed in cottonseed oil (Han et al., 1994).

The canned SOCO was one of the most important and representative exporting canned seafoods in Korea through last 20 years. But the conventional sterilization process has been followed the cannery sterilizing conditions required by foriegn buyers without any considerations or studing the relation among the energy consumption, microbiological safety and quality of products. The minimal holding time required by the foreign buyers is at least 70min at 113.5℃ in saturated steam. But the practical sterilization has been carried out usually at higher temperatures, such as 114~116℃ with the holding time of 70~75min. Such sterilizing conditions correspond to equivalent F_0-values more than 10min.

While, Heiss and Eichner (1984) reported in a reviewing table that the reasonable F_0-values for commercially sterilized canned oyster were in the range of 5.9~6.0min for Atlantic oyster and 2.7~6.0min for Pacific oyster. Thus, it is clear that the Korean canned SOCO has been produced by excessive heating. But until now, a reasonable F_0-value was not established for the Korean canned SOCO. On this account, we tried to suggest a rational F_0-value criterion for the commercial sterilizing process of the canned SOCO to minimize the energy consumption as one part of process optimization.

Materials and methods

Test Product: The canned SOCO was prepared on March 1993 in Jinyang Fishery Co. Ltd. in Geoje island in Kyoungnam, and on March 1994 in Yeonsung Corporation in Yeosu city in Jeonnam, Korea. Oyster (*Crassostrea gigas*) cultured on the coast of Korean southern sea was used as raw materials for the SOCO. Immediately after harvesting, the fresh oyster was shucked, washed, smoked, and 96g of the smoked oyster with individual weight of 10~15g was packed in a hexahedron type can (106.2mm×74.6mm×22.0 mm) with 24g of cottonseed oil by the conventional canning procedure. After vacuum sealing, the cans were stored at -40℃ for later experiments. Before sterilizing experiments, the frozen cans were thawed in a temperature controlled water tank for approximately 4 hours to insure the homogeneity of the oyster.

F_0-value measurement: The F_0-values were measured in a vertical still-retort equipped with automatic lethal rate measuring system (An et al., 1992, Cho et al., 1992, Han and Kim, 1995) under different sterilizing conditions. The lethal rates were measured using following equation in every 0.2 sec (Cho et al., 1992), and the integrated lethal rate during the whole process was regarded as F_0-value as in equation (1).

$$F_0 = F^{z=10℃}_{T=121.1℃} = m \cdot D_{121.1} = \sum_0^t L \cdot \Delta t \qquad (1)$$

where F_T and z are the sterilizing time at T℃ and z-value. $D_{121.1}$, m, L and t are D-value at 121.1 ℃, sterilizing value, lethal rate and thermal treatment time, respectively.

Analytical procedures: 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 aminonitrogen (NH_2-N) were determined by the methods of Miwa and Iida (1973) and Spies and Chamber (1951), and the acid value (AV) and thiobarbituric acid (TBA) value were determind by the methods of A.O.A.C. (1982), respectively.

Microbiological experiments: Counting, isolation and identification of viable cells were carried out by the methods of A.P.H.A. (1984), Colwell and Liston (1960), Gibbs and Skinner (1966), Harrigan and MaCnee (1976), Collins and Lyne (1976) and Bergey's Manual of Systematic Bacteriology (Baumann et al., 1984).

The aerobic plate count was carried out at 20℃ for 4 days with proteose peptone-beef extract agar medium containing 0.5% of sodium chloride, and the facultative anaerobic plate count also at 28℃ for 4 days using an oxoid gas pack jar with trypticase peptone-glucose-yeast extract agar medium. The detection of yeast and mold was carried out with acidified potato dextrose agar medium. The thermoduric and thermophilic microorganisms were isolated by the method of A.P.H.A. (1984). Bacterial spores were produced by growing cells described by Lee and Chang (1982), and heat resistances of bacterial spores were measured by the TDT-tube method (Stumbo, 1973; Cho, 1993).

Results and Discussion

Changes in proximate composition: Table 1 showed the proximate composition and some chemical values of the raw oyster and canned SOCO before sterilization. There were remarkable differences in content of each component except the ash content and pH. It was considered that the differences were resulted mainly due to the cooperative influence of dehydration of the oyster during smoking and addition of cottonseed oil. The slight increase of NH_2-N content might be resulted from the thermal degradation of protein (Jung et al., 1994). Viable cell count of the raw oyster was increased from 1.4×10^2 to 3.3×10^4/ml, and VBN content of the canned SOCO before sterilization was increased also slightly during the pre-

Table 1. Proximate composition, chemical values and number of viable cell of raw oyster and canned SOCO before sterilization

Components	Contents	
	Raw oyster	SOCO before sterilization
Moisture(%)	75.4	54.5
Crude protein(%)	11.4	15.3
Crude lipid(%)	2.2	19.8
Crude ash(%)	2.8	3.0
pH	6.01	5.99
NH_2-N(mg/100g)	34.0	38.0
VBN(mg/100g)	7.24	9.8
Viable cell(counts/ml)	1.4×10^2	3.3×10^4

treatment. It meant that the pretreatment time before sterilization should be shortened as much as possible to prevent the growth of microorganisms.

Microflora in oyster: Viable cell concentrations in the raw and pretreated oyster were in the range of 1.4×10^2~3.3×10^4 (Table 1). In the raw oyster, Genus *Moraxella* and *Vibrio* were most common, and generally Gram positive microorganisms were frequently detected, as shown in Table 2. Most of the microflora were putrefactive, and also thermoduric or thermophilic bacteria, including *Bacillus* sp. were presented. They could cause a serious deterioration and declining freshness during the pretreatment. If the sterilization was not executed immediately after pretreatments of the raw oyster, the concept of commercial sterilization became meaningless. Such phenomenon could also be recognized in the canning of tuna meat packed in coottonseed oil (Han et al., 1994). It meant again that the processing time before sterilization should be shortened as much as possible.

F_0-values and microbiological safety: Table 3 showed the microorganisms detected from the canned SOCO immediately after sterilization at 110℃ under different time-temperature conditions. *Bacillus* sp., *Clostridium* sp., *Corynebacterium* sp. and *Staphylococcus* sp. which were not detected in the raw oyster with the exception of *Bacillus* sp. were detected. It was considered that they could not be detected by enrichment culture method used for raw oyster, because prolific and putrefactive microbes interfered the growth of these microbes.

Only *Bacillus* sp. were detected after sterilization under the conditions of F_0-values less than 5.92min, i.e. 3.95min. It is well known that Gram positive cocci and *Bacillus* sp. are natural flora in oyster and also present in oyster which is cultured in UV treated

Table 2. Microflora in raw oyster*

Strains	%	Strains	%
Moraxella sp.	25.0	*Coliform*	9.0
Vibrio sp.	15.5	*Bacillus* sp.	8.0
Pseudomonas sp.	12.3	The others	20.6
Flavobacterium sp.	9.6		

* Microflora in raw oysters refered to microorganisms which were present in freshly shucked oyster before washing.

Table 3. Microflora in the canned SOCO immediately after sterilization at 110℃ (% of total aerobic or facultative anaerobic bacterial count)

Genus	Oxygen* requirement	F_0-value in min			
		0.7	1.29	3.95	5.92
Bacillus	A	100.0	98.0	100.0	-
Clostridium	A	-	2.0	-	-
Bacillus	FA	55.5	75.8	100.0	-
Clostridium	FA	20.3	24.2	-	-
Corynebacterium	FA	12.5	-	-	-
Staphylococcus	FA	11.7	-	-	-

A: aerobic, FA: Facultative anaerobic.

Table 4. Heat resistance data of spores of *Bacillus* sp. isolated from the raw oyster and *Bacillus stearothermophillus* PS 1315

Strains	Heating medium	$D_{121.1}$ (min)	z-value (℃)	Activation energy (J/Kg mol)
Bacillus sp.	P*	0.07	12.78	203×10^6
	M*	4.10	10.91	261×10^6
Bacillus stearothermophillus PS 1315	P*	5.20	12.58	230×10^6
	M*	12.34	12.07	254×10^6

P: phosphate buffer solution (0.1M, pH 7.0), M: SOCO homogenate

sea water. These thermophilic microorganisms can cause spoilage of low acidic food which is left at 43℃ after insufficient sterilization (Mitscherlich and March, 1984).

The sterilizing condition which guarantees no detection of thermophilic or thermoduric microorganisms, such as *Bacillus* sp., may be regarded as practical optimal criterion for microbiological safety of commercially sterilized foodstuffs. In the case of the canned SOCO with F_0-values of 5.92min and over, *Bacillus* sp. were not detected. But in the canned SOCO left overnight (more than 24hr) after pretreatment at room temperature before sterilization, *Bacillus* sp. were detected under the same sterilizing condition (data were not shown). It was considered that immediate sterilization after pretreatment of raw material as well as pretreatment time and sterilizing condition was important factor which could affect on the microbiological safety of the canned SOCO.

Heat resistances of bacterial spores: *Bacillus subtilis*, *Bacillus cereus* and *Bacillus pasteurii* were isolated from the raw and precooked tuna meat (Han et al., 1994). The most heat resistant spore-forming bacteria isolated from the raw oyster were also *Bacillus* sp.. As shown in Table 4, the D-values of spores of *Bacillus* sp. at 121.1℃ was 4.10min in the SOCO homogenate. The correlation coefficient of thermal death time curve determined to analyse the thermal characteristics was greater than 0.9. The D-value of *Bacillus* sp. spores at 121.1℃($F_{121.1}$) was ca. 1/3 of that of *Bacillus* stearothermophilus PS 1315, one of the most heat resistant microorganism often found in low acidic canned foods. The theoretical $F_{121.1}$ calculated for m=4 in equation (1) for the *Bacillus* sp. spores with z=10.91℃ in the canned SOCO was 16.4min. The corresponding $F_{113.5}$ calculated by equation (2) for conventional sterilization at 113.5℃ with z=10.91℃ was 81.6 min, and this thermal processing time was equiva-

Table 5. Changes of viable cell count in the canned SOCO during storage

F_0-value (min)	Storage temp. (℃)	Storage days				
		0	30	60	90	120
1.41	5	-	3.4×10^2	1.0×10^4	1.0×10^6	1.0×10^6
	25	270	4.4×10^2	5.4×10^2	1.0×10^4	1.0×10^6
	50	-	1.0×10^6	1.0×10^6	1.0×10^6	1.0×10^6
3.09	5	-	-	-	>30	1.4×10^2
	25	-	-	>30	1.4×10^2	2.2×10^2
	50	-	1.3×10^2	3.2×10^2	4.4×10^2	1.8×10^3
5.92	5	-	-	-	-	-
	25	-	-	-	-	-
	50	-	-	-	-	-
9.42	5	-	-	-	-	-
	25	-	-	-	-	-
	50	-	-	-	-	-

lent to the theoretical F_0-value 14.17min at 121.1℃ for the *Bacillus* sp. spores with $z=10$℃.

$$F_{T1}=F_{T2}\cdot 10^{(T2-T1)/z} \quad (2)$$

Changes of viable cell count during storage: The products sterilized at 110℃ with different F_0-values were stored at 5℃, 25℃ and 50℃, and the viable cell concentration during long-term storage was determined. No viable cell was detected in the products with F_0-value of 5.92min and over, although the theoretical F_0-value calculated with equation (2) was 14.17min for the canned SOCO, as shown in Table 5. Such phenomena were also recognized in the canned tuna meat packed in cottonseed oil (Han et al., 1994). Moreover, Heiss and Eichner (1984) reported in a reviewing table that the proper F_0-values for commercially sterilized canned Pacific oyster were in the range of 2.7~6.0min. Therefore, it was considered that the reasonable F_0-value was *ca.* 6.0min.. According to the analysis of time-temperature profiles, the energy required to the practical sterilization at 113.5℃ could be saved by 30%.

Conclusion

F_0-values of the canned SOCO were measured under various sterilizing conditions, and the microbiological safety of the products was evaluated to establish an optimal F_0-value criterion. Most of the microorganisms in the raw oyster were prolific and putrefactive. No microorganisms were detected during storage at 50℃ for 120 days from the canned SOCO, which was pretreated by conventional procedure and sterilized at 110℃ with F_0-value of 5.92min and over. The most heat resistant microflora isolated from the raw oyster was *Bacillus* sp.. The D-value at 121.1℃ and z-value in the SOCO homogenate were 4.10min and 10.91℃, respectively. After 4 months storage at 50℃, no growth of microorganisms was recognized from the products with F_0-value of 5.92min. Therefore, it was considered that the reasonable F_0-value for the sterilization of the canned SOCO was 6.0min.

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훈제 굴 통조림의 가열살균기준 설정에 관한 연구

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훈제 굴 기름담금 통조림은 우리 나라의 대표적인 수출용 수산물 통조림이지만, 가열살균공정의 기준이 정립되어 있지 않아서 생산공정에서 과잉열처리와 그에 따른 에너지의 낭비 및 품질저하를 피하지 못하고 있다. 따라서 본 연구에서는 가열살균공정에서의 에너지 소비와 제품의 미생물학적 안전성을 최적화하고자 하였다.

원료 생굴에서 검출된 대부분의 미생물은 증식속도가 빠르고 부패력이 강한 것이었다. 정상적인 전처리 후에 110℃에서 F_0-값 5.92min으로 살균한 훈제 굴 기름담금 통조림에서는 장기 저장중에도 미생물이 전혀 검출되지 않았다. 따라서 훈제 굴 기름담금 통조림의 F_0-값으로는 6.0min 정도가 적당한 것으로 판단되었다.