Studies for Reestabilishment of Approval Toxin Amount in Paralytic Shellfish Poison-Infested Shellfish

1. Toxicity Change in Paralytic Shellfish Poison-Infested Blue mussel, *Mytilus edulis* and Oyster, *Crassostrea gigas* during Boiling and Canning Processes

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The studies on the detoxification of paralytic shellfish poison (PSP)-infested blue mussels, *Mytilus edulis* and oyster, *Crassostrea gigas* were performed for using of available processing resource. Toxic blue mussel and oysters from Nampo in Masan Bay, Hachong in Kǒje Bay and Woepori in Kǒje were used for experimental samples. The toxicity of low toxic blue mussel (A, 84 μg/100 g; B, 166 μg/100 g; C, 295 μg/100 g; D, 557 μg/100 g) and oyster (740 μg/100 g) were reduced below the regulation limit of PSP (80 μg/100 g) or undetected level by mouse bioassay after boiling at 98℃ for 10 min and retorting at 115℃ for 70 min, while the toxicity of high toxic blue mussel (E, 8,760 μg/100 g) remained beyond the regulation limit after boiling and retorting at same condition. These results suggested that the regulation limit of PSP could be level up from (80 μg/100 g) to about 160 μg/100 g.

Key words : paralytic shellfish poison (PSP), detoxification, blue mussel, oyster, canned shellfish, the regulation limit of PSP

Introduction

Paralytic shellfish poison (PSP), a severe and occasionally fatal form of food poisoning caused by the ingestion of certain shellfish which have taken a toxic dinoflagellates such as *Alexandrium catenella* and *Alexandrium tamarense*. Much of the early history of PSP was reviewed by Halstead (1965) where over 900 cases and over 200 fatalities were listed from many countries between 1689 and 1962. In late May, 1986, two men were died by ingesting wild blue mussel, *Mytilus edulis*, grown at bottom of an anchored waste ship to be dismantled at Gamchǒn Bay, Pusan, Korea (Chang et al., 1987) and two men were also died by ingesting wild blue mussel, *Mytilus edulis*, grown on breakwater on 15th May, 1996, at Woepori, Kǒje, Korea (Sin-Kyeongnam Ilbo, 1996). Toxication of commercially important shellfish with PSP cause serious problems to public health and shellfish related industry.

Of the several methods proposed for removal of PSP from toxic shellfish, heat treatment has been the most popular, although a large percentage of the occurrences of PSP illness has been related to the ingestion of cooked shellfish. Prakash et al. (1971) reported that the total toxicity in the scallop was decreased about 90% during canning. Noguchi et al. (1980a, b) also demonstrated that a significant reduction of toxicity in the Japanese scallop, *Patinopecten yessoensis* was occurred during retorting and that the slow but

Table 1. List of tested samples

Sample name	Sample code	Collected date	Collected station	Toxicity (μg/100g)
Blue mussel	A	96. 3. 18	Nampo, Masan Bay	84
〃	B	96. 4. 08	Nampo, Masan Bay	166
〃	C	96. 5. 03	Nampo, Masan Bay	295
〃	D	96. 5. 10	Hachŏng, Kŏje Bay	557
〃	E	96. 5. 18	Woepori, Kŏje	8,760
Oyster		96. 5. 18	Woepori, Kŏje	740

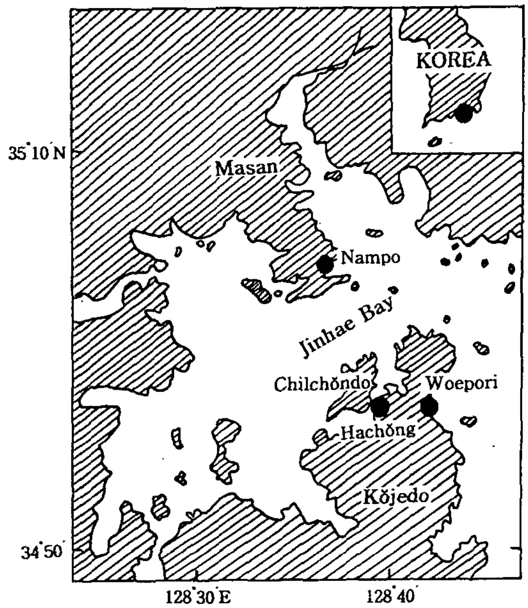

Fig. 1. Sampling stations of blue mussel and oyster.

steady reduction of the remaining toxicity in canned scallop occurred during storage. However, the study on the detoxification of toxic shellfish in different toxicity level is not so much. This study was performed to suggest a modified regulation limit of PSP for shellfish to be heat-process.

Materials and Methods

Materials

The cultured blue mussel, *Mytilus edulis* were collected from Nampo, Masan Bay, Hachŏng, Kŏje Bay and Woepori, Kŏje, Korea. Wild blue mussel, *Mytilus edulis* and wild oyster, *Crassostrea gigas* were also collected from Weopori, Kŏje, Korea (Fig. 1). The specimens with toxicity of 84 μg~8,760 μg/100 g were experimented in the canning factory, Daeil Fisheries Ltd Co. (Table 1).

Boiling

The 360 g of washed shell-stock blue mussel was cooked at 98℃ for 10 min. with two volumes of fresh water.

Canning

Shell-stock blue mussel and oyster washed with fresh water were steamed at 105℃ for 10 min., shucked and trimmed, respectively. The 165 g of steamed meat were packed in No. 7 can with 100 ml of 2% NaCl solution and retorted at 115℃ for 70 min. (Boiled can). The steamed meat were smoked at 110℃ for 15 min., followed at 125℃ for 15 min., next. The 60 g of smoked meat was packed in No. 3B of square can with 50 ml of cotton seed oil and retorted at 115℃ for 70 min. (Smoked can). The 95 g of steamed meat were packed in No. 3B of square can with 20 ml of acidified cotton seed oil (cotton seed oil, 1000 ml; paprika, 1.7 g; chilly oil, 0.8 g; Acetic acid 250 ml) and retorted at 115℃ for 70 min. (Acidified can).

Toxicity

PSP toxicity was determined by mouse assay method using ICR strain male mice weighing 19~21 g following the AOAC method (Association of Official

Table 2. Toxicity change of blue mussel during boiling (98℃, 10 min.)

Process	960408 (A)			960503 (B)			960510 (C)			950512 (D)			960518 (E)		
	Weight (g)	Toxicity (μg/100 g)	Reduction rate (%)	Weight (g)	Toxicity (μg/100 g)	Reduction rate (%)	Weight (g)	Toxicity (μg/100 g)	Reduction rate (%)	Weight (g)	Toxicity (μg/100 g)	Reduction rate (%)	Weight (g)	Toxicity (μg/100 g)	Reduction rate (%)
Shell stocked blue mussel	360	84		360	166		360	295		360	557		360	8,760	
Boiling															
Boiled meat	80	ND*	100	57	ND	100	76	40	87	111	45	92	63	2,365	73
Soup	275	ND		323	ND		422	13		374	19		230	1,792	

* ND, not detected.

Table 3. Toxicity change of blue mussel during smoked canning process

Process	960408 (A)		960503 (B)		960510 (C)		950512 (D)		960518 (E)		960521 (Oyster)	
	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)
1. Shell stocked	84		166		295		557		8,760		740	
2. Steaming												
Steamed meat	ND*	100	38	77	38	87	75	87	3,927	55	399	46
Broth	ND		ND		ND		ND		820		189	
3. Smoked meat	39	100	39	76	41	86	49	91	3,528	60	315	57
4. Canning												
Canned meat	ND	100	ND	100	ND	100	38	93	231	97	ND	100
	ND	100	ND	100	ND	100	38	93	210	98	40	94
	ND	100	ND	100	ND	100	37	93	189	98	40	94
Soup	ND		ND		ND		ND		26		ND	
	ND		ND		ND		ND		26		ND	
	ND		ND		ND		ND		24		ND	

* ND, not detected.

Analytical Chemists, 1990). Ten mice were used for each sample and the mean toxicity was expressed as μg per 100 g of edible meat or μg per 100 g of soup. The toxicities of can products were measured in triplecately sample. The toxicities of steamed broth and canned soup were measured by concentrating under reduced pressure if their toxicities were not detected by mouse assay.

Results and Discussion

Change of toxicity by boiling

Changes of toxicity in different toxic level of the blue mussel by boiling were summarized in Table 2.

The toxicities of low toxic blue mussel, A (84 μg/100 g), B (166 μg/100 g), C (295 μg/100 g) and D (557 μg/100 g) were reduced below the regulation limit of 80 μg/100 g. Boiling the blue mussel for the usual home cooking times reduced their toxicity by 87~100 %. This is similar to the results of Takada et al. (1994) in which the detoxification ratio of oyster was 83 % when the oyster was boiled at 98℃ for 10 min.

While, the residual toxicity of 2,365 μg/100 g was still existent in the high toxic blue mussel E of 8,760 μg/100 g after boiling although their detoxification ratio was 73%.

These results indicated that boiling may detoxicate PSP, but the boiling itself was not sufficient to detoxicate extremely high toxic shellfish. In fact, almost of the recorded food poisoning have been come from eating cooked shellfish.

Change of toxicity during canning process

Most commercial catches of shellfish are processed before marketing and toxicities of the processed products depended on the processing method.

The most common commercial processing treatments for shellfish are canning.

1. Change of toxicity during smoked canning process

Changes of toxicity in blue mussel and oyster during smoked canning process were shown in Table 3.

The toxicities of the low toxic blue mussel, A (84 μ 100 g), B (166 μg/100 g) and C (295 μ100 g), were reduced below the regulation limit of 80 μg/100 g after steaming as same as boiling. Moreover, The toxicities of three samples (A, B and C) were not detected after retorting at 115℃ for 70 min. Blue mussel D of 557 μg/100 g in which its toxicity was about 7 times greater of the regulation limit was reduced to 37~38 μg/100 g below the regulation limit after retorting. In the other hand, the extremely high toxic blue mussel E of 8,760 μg/100 g in which its toxicity is about 110 times greater of the regulation limit, still showed the mean toxicity of 189~231 μg/100 g after retorting although the detoxification ratio was 98%.

In oyster of 740 μg/100 g, the toxicity of 315 μg/100 g remained after smoking process, but the toxicity was also reduced to 40 μg/100 g, below the regulation limit after retorting process.

2. Change of toxicity during boiled canning process

Change of toxicity in blue museel and oyster during boiled canning process were shown in Table 4.

There were no difference in the detoxification effects of blue mussel and oyster between boiled can process and smoked can process. Especially, the detoxification ratio (D, 93%; E, 98%) and the residual toxicity (D, 39~40 μg/100 g; E, 190~232 μg/100 g) by boiled can process were almost the same as smoking canning process although the boiled can process had not smoking process. The toxicity in oyster was also not detected after retorting.

93~100% of the toxicity in raw toxic shellfish meat could be removed from the meats or destroyed by canning is similar to the tests with sea scallop and oyster in which the toxicity was reduced to 90% (Noguchi et al., 1980a and 1980b; Takata et al., 1994).

3. Change of toxicity during acidifying canning process

Change of toxicity in blue museel and oyster

Table 4. Toxicity change of blue mussel and oyster during boiled canning process

Process	960408 (A)		960503 (B)		960510 (C)		950512 (D)		960518 (E)		960521 (Oyster)	
	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)
1. Shell stocked	84		166		295		557		8,760		740	
2. Steaming												
Steamed meat	ND*	100	38	77	38	87	75	71	3,927	55	399	46
Broth	ND		ND		ND		54		820		189	
3. Canning												
Canned meat	ND	100	ND	100	ND	100	40	93	232	97	ND	100
	ND	100	ND	100	ND	100	40	40	211	98	ND	100
	ND	100	ND	100	ND	100	39	39	190	98	ND	100
Soup	ND		ND		ND		ND		28		ND	
	ND		ND		ND		ND		28		ND	
	ND		ND		ND		ND		26		ND	

* ND, not detected.

Table 5. Toxicity change of blue mussel and oyster during acidified canning process

Process	960408 (A)		960503 (B)		960510 (C)		950512 (D)		960518 (E)		960521 (Oyster)	
	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)	Toxicity (μg/100 g)	Reduction rate (%)
1. Shell stocked	84		166		295		557		8,760		740	
2. Steaming												
Steamed meat	ND*	100	38	77	38	87	75	87	3,927	55	399	46
Broth	ND		ND		ND		54		820		189	
3. Canning			ND									
Canned meat	ND	100	ND		41	86	41	93	278	97	65	91
	ND	100	ND		41	86	41	93	295	97	84	89
	ND	100	ND		41	86	40	93	302	97	71	90
Soup	ND		ND		ND		28		32		ND	
	ND		ND		ND		30		32		ND	
	ND		ND		ND		28		28		ND	

* ND, not detected.

during acidifying canning process were shown in Table 5.

The toxicities of the low toxic blue mussel, A, B and C, were not detected after retorting, the same as in smoked can and boiled can. The toxicity of sample D was also reduced below the regulation limit after retorting. In the blue mussel E, however, the residual toxicity (278~302 μg/100 g) after retorting were higher than those of smoked can and boiled can. In oyster, 84 μg/100 g of the residual toxicity was detected in one of three cans.

PSP was thermostable at range of pH 2~4. (Chang et al., 1988) The residual toxicities of blue mussel E and oyster in acidified can were supposed to be higher than those of smoked can and boiled can because pH of acidified can was about 4.5.

From above results, common commercial canning process reduced toxicity by more than 90%. Steaming reduced 46~87% of total toxicity and retorting produces a further small drop in toxicity (equivalent to 5~30% of toxicity of raw shellfish). We found that toxicities of raw shellfishes affected their canned toxicity and showed that toxin-free cans were regularly obtained when toxicity of raw shellfish were below 295 μg/100 g and that toxicity of cans less than 80 μg/100 g were regularly obtained when toxicity of raw shellfish were below 557 μg/100 g.

In the current control program of the Food Sanitation Law in Korea, when PSP toxicity in any area exceed 80 μg/100 g of edible meat, all areas in its class are closed to harvest shellfishes for all purpose. This might provide consumers a wide margin of safety but this would reduce many fishermen's and processors' income and would take away the livelihood of many others. Possibly the regulation should be relaxed somewhat, because there is evidence that raw shellfish with toxicity of 557 μg/100 g produces cans scored less than 80 μg/100 g. Toxin-free canned shellfish are regulary obtained from stocks with raw toxicity of 295 μg/100 g or less (Table 3, 4 and 5). In Canada, raw shellfish with toxicity of 80~160 μg/100 g has been permitted for canning only since 1971. If the final toxicities of cans are below 80 μg/100 g, the cans are released for marketing (Praksh et al., 1971). These results, therefore, suggest that the regulation limit can be also level up more than raw scores of 80 μg/100 g for canning in Korea. But if scores still exceed 80 μg/100 g, the cans must be destroyed.

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