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Difference of Toxicities among Tissues in the Pufferfish *Fugu xanthopterus* ("Ggachibog")

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Twenty-four specimens of the pufferfish *Fugu xanthopterus*, Korean name, "Ggachibog", collected at a fish market of Pusan were examined for anatomical distribution of toxicity by the mouse bioassay method. Frequency of toxic specimens was 88, 75, 54, 13, 71, 80 and 71%, in terms of liver, intestine, skin, muscle, testis, ovary and bile, respectively. Their the highest toxicity scores were 417, 387, 112, 17, 39, 403 and 178 MU/*g*, respectively; and average toxicity values were 110± 25.0(mean± S.E.), 73± 20.3, 17.8± 5.1, 2.7± 1.1, 15.6± 5.4, 115± 33.0 and 34± 9.3 MU/*g*, respectively. A significant correlation between the toxicities of liver and intestine(r=0.93), between those of liver and skin (r=0.79) and between those of liver and ovary(r=0.83) was observed.

Introduction

It is known that the puffer contains tetrodotoxin (TTX) in some tissues throughout the year. Noguchi et al.(1971, 1988) and Hwang et al.(1988) studied toxicities of puffers in different species, tissues and localities. Puffers inhabit at least 30 species in adjacent coast of Korea according to Jeong (1977). One of them, puffer *Fugu xanthopterus* is regarded as one of the delicious species in Korea. The muscle to be eaten is generally nontoxic, whereas tissues such as liver and ovary are often toxic due to the presence of TTX. Actually, food poisoning cases have sporadically been caused by those toxic tissues in Korea. However, little research has been conducted to the toxicities of Korean puffers.

The purpose of this study was to assay for the anatomical distribution of toxicity, and to determine the correlation between toxicities of each tissue in the puffer *F. xanthopterus* specimens.

Materials and Methods

Materials

24 specimens of the pufferfish, *F. xanthopterus*, (Fig. 1) were collected at a fish market of Pusan in April, through November, 1990(Table 1.)

All of them were frozen immediately and kept -20℃ until used for toxicity assay.

Assay of Toxicity

Toxicity was assayed by the official TTX method of the Ministry of health and Welfare, Japan(1978). A pufferfish was dissected into seven parts such as liver, intestine, skin, muscle, testis, ovary and bile. The tissues were homogenized, heated, added with 0.1% acetic acid and examined for toxicity.

One mouse unit(MU) was defined here as the amount of toxin which was able to kill a mouse (ICR, male, 18~21 *g*) at 30 min.

Results and Discussions

As shown in Table 1, seven tissues of 24 speci-

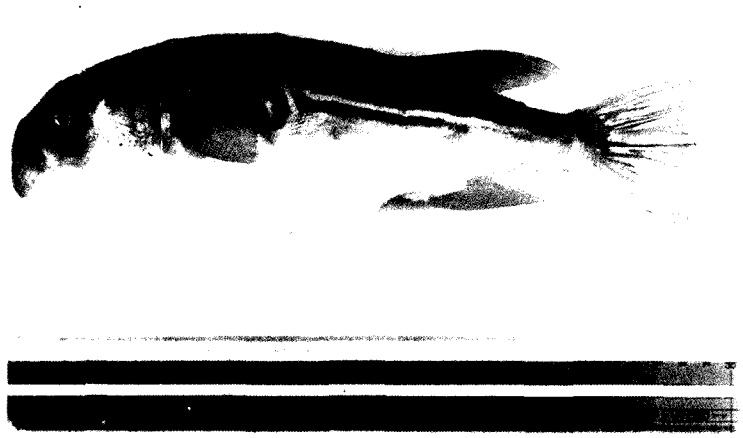

Fig. 1. Pufferfish, *F. xanthopterus*(Korean name, Ggachibog)

Table 1. Toxicity of 24 specimens of the puffer *Fugu xanthopterus*, collected at Pusan.

Specimen No.	Sex[a]	Toxicity (MU/g)							Total Toxicity (MU)
		Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	
1	F	12	11	8	6	-[b]	14	11	4,036
2	F	8	ND[c]	ND	ND	-	6	ND	419
3	F	19	9	ND	ND	-	11	8	1,080
4	F	14	9	ND	ND	-	9	13	823
5	F	19	6	7	ND	-	30	10	1,734
6	M	22	14	11	ND	16	-	ND	1,930
7	F	365	272	31	ND	-	215	27	22,814
8	F	195	67	69	17	-	123	20	18,713
9	M	47	50	38	ND	29	115	28	5,833
10	F	ND	ND	ND	ND	-	ND	ND	0
11	M	258	107	21	8	14	314	28	17,142
12	F	112	74	22	ND	-	53	15	6,909
13	M	48	14	16	7	ND	-	ND	5,896
14	M	ND	ND	ND	ND	ND	-	ND	0
15	F	131	77	11	ND	-	216	23	8,475
16	F	417	387	112	15	-	403	137	36,186
17	M	25	12	ND	ND	11	-	16	1,095
18	M	49	19	ND	ND	-	-	12	2,349
19	M	115	87	19	ND	-	-	74	6,645
20	F	56	18	ND	ND	-	16	27	2,868
21	F	325	186	30	ND	-	110	178	16,594
22	F	167	98	27	ND	-	246	105	10,738
23	F	201	217	16	11	-	272	27	18,023
24	M	42	18	ND	ND	39	-	56	1,899

a, M: Male F: Female
b, Not Assayed
c, Not Detected

mens were examined. The mean total length and the body weight were 30 *cm* and 507 *g*, respectively. Also, frequency of toxicity, the highest toxicity and average toxicity in each tissue of the specimen were presented in Table 2.

As indicated in Table 2, the specimens had a toxic liver frequency of 88% with the highest toxicity score of 417 MU/*g* and the average toxicity score of 110± 25 MU/*g*. Livers of 10 specimens were strongly toxic and those of 11 specimens were weakly toxic except for 3 specimens among 24 samples.

Three-fourths of the specimens were shown to be toxic except for 6 specimes in the intestine as shown in Fig. 2. The sample had the highest score of 387 MU/*g* and the average toxicity score being 73± 20.3 MU/*g*. In addition, the tissue revealed the frequency of toxic specimen being 75%.

The skin of this pufferfish, according to the report of Jeong(1990), was found to have weak toxicity, 6~40 MU/*g*, depending upon the specimens. In our study, as demonstrated in Table 2, the toxicity of 13 specimens was weakly toxic and 11 specimens were non-toxic with an average toxicity value of 17.8± 5.1 MU/*g* in the skin. And also, the frequency of toxic skin was 54%.

Most muscles were revealed to be non-toxic except for three specimens. These results were similiar to the report of Jeong(1990). The average value of toxicity in the muscle was found to be 2.7± 1.1 MU/*g* and the highest toxicity was recorded 17 MU/*g*. The frequency of toxic specimens was 13%. The toxicity score was clearly lower than that of any other tissues in all the specimens assayed.

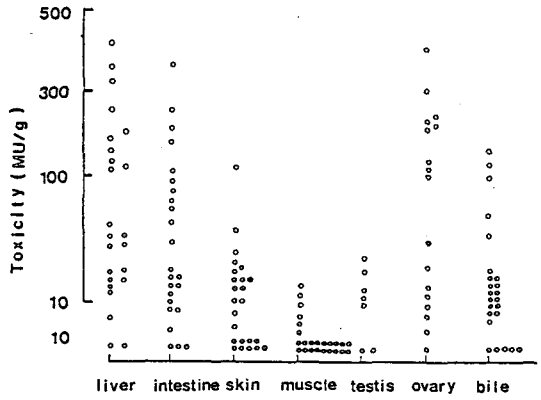

Fig. 2. Anatomical distribution of toxicity in the pufferfish *F. Xanthoptrous* specimens.

In spite of having weak toxicity in the testis of the pufferfish, the frequency of toxic specimens showed somewhat high value of 71%. In the case of testis, the average toxicity and the highest toxicity were 15.6± 5.4 MU/*g* and 39 MU/*g*, respectively. Two of testis assayed were non-toxic except for 5 specimens which were weakly toxic among 7 specimens with the lethal potency ranging from 11 to 39 MU/*g*.

In the ovary, more than a half of the specimens were shown to be toxic with the exception of 3 among 15 specimens and 7 specimens out of them were strongly toxic. The ovary was found to be the highest toxicity score being 403 MU/*g* and the frequency of toxic specimens was 80% (115± 33 MU/*g*, mean± S.E.) from the data given.

Table 2. Toxicity in each tissues of 24 specimens of puffers fish *Fugu xanthopterus*, collected at Pusan.

Tissue	Frequency of Toxic Specimens(%)	No. of Specimens[a]			Highest Toxicity (MU/*g*)	Average Toxicity ± S.E.(MU/*g*)
		Strongly Toxic	Weakly Toxic	Non-Toxic		
Liver	88(21/24)[b]	10	11	3	417	110.0± 25.0
Intestine	75(18/24)	5	13	6	387	73.0± 20.3
Skin	54(13/24)	0	13	11	112	17.8± 5.1
Muscle	13(3/24)	0	3	21	17	2.7± 1.1
Testis	71(5/ 7)	0	5	2	39	15.6± 5.4
Ovary	80(12/15)	7	5	3	403	115.0± 33.0
Bile	71(17/24)	3	15	6	178	34.0± 9.3

a, Strongly Toxic, 100~999 MU/*g*; Weakly Toxic, 10~99 MU/*g*; Non-Toxic, <10MU/*g*.
b, Numbers in parenthesis represent toxic specimens/total specimens. "Toxic" defined here is >10 MU/*g*.

It was noteworthy that strongly toxic tissues were found, though sporadically, in the bile of these puffers where the average toxicity levels were weakly toxic. The frequency of toxic specimens was 71% with average toxicity of 34± 9.3 MU/*g* and the highest toxicity score of 178 MU/*g*.

Correlation of the Toxicity between each Tissue of Pufferfish

Kanoh et al.(1985) reported that toxin transfer among tissues of puffers could be depended upon interrelation between toxicities of liver and bile or between those of bile and intestine.

In this study, such tendency was observed statistically significant correlation among toxicities of tissues. Firstly, Fig. 3 indicated that there was significant correlation between the toxicities of liver and intestine. It was supposed that nontoxicities detected in liver were, therefore, also related to formative nontoxicities in intestine. The results indicated that the toxicities existed in 21 livers and 18 intestines out of each of 24 tissue samples of puffers. The coefficient of correlation (r) in toxicities between liver and intestine was shown 0.93. Secondly, Fig. 4 illustrated interrelationship between those of liver and skin. Generally, nontoxicites in the liver of puffers also appeared to be nontoxic in skin of them, while either strong or weak toxicity of liver resulted in slight increase of toxin content in the skin. Result of a coefficient correlation (r) indicated to be 0.79 between those of them. Finally, toxicity of betwen liver and ovary was presented in Fig. 5. The correlation between those of liver and ovary was also significant(r=0.83).

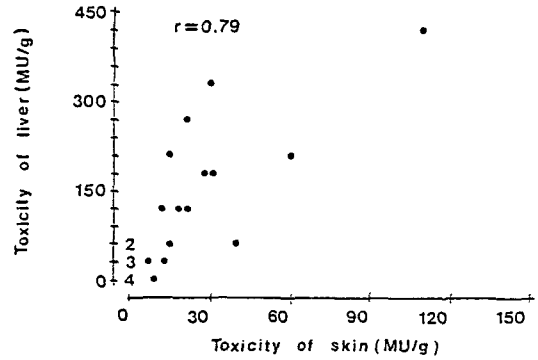

Fig. 4. Correlation between toxicities of liver and skin in the pufferfish *F. Xanthopterous* specimens.

As described above, 24 easily obtainable specimens of the puffer, *F. xanthopterus*, were examined for anatomical distribution of toxicity and correlation among toxicites of tissues. In our study, like other toxic puffers, most of non-edible parts were found to possess toxin, while the testis, skin and muscle of these puffers were nontoxic or weakly toxic, depending upon the specimen. It follows therefore that liver was more toxic than other tissues in the specimens, that the frequency of toxicity and the average toxicity were roughly comparable to that of other tissues, and that the liver was sometimes toxic enough to kill a man even when ingested in small amount. In toxicological studies of Japanese puffers, Tani(1945) suggested that minimun

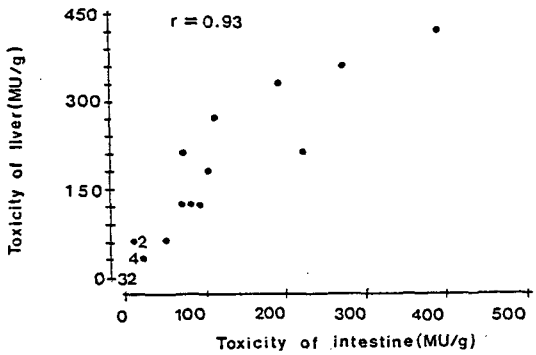

Fig. 3. Correlation between toxicities of liver and intestine in the pufferfish *F. Xanthopterous* specimens.

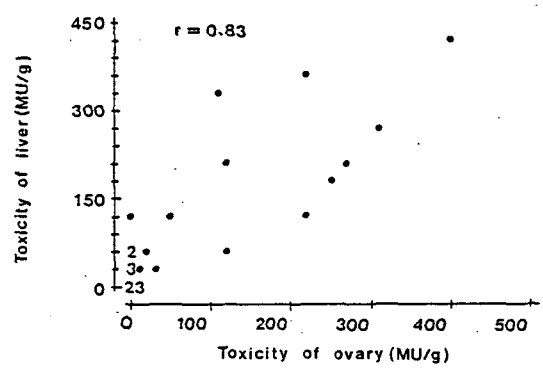

Fig. 5. Correlation between toxicities of liver and ovary in the pufferfish *F. Xanthopterous* specimens.

lethal dose of TTX in human was estimated to be 10,000 MU. It was reported that the same kind of specimens maintained a fairly different toxicity level in various puffers by Kanoh et al.(1983). Especially, it was demonstrated that individual variation was observed among the specimens caught at the same time and place.

Sekio et al.(1984) reported that there were correlated with among toxicities of tissues and the results of our expriment were similar to that of Sekio et al.(1984). On the other hand, according to Saito et al.(1984) in study of resistibility of toxic and nontoxic puffer against TTX, it was of interest that the even though cultured puffers of "torafugu" had been demonstrated to be nontoxic, these puffers were toxified when fed with a TTX containing diet for 37 days. With these results, the present data may also give support to account for the mechanism, which TTX arises from the food chain in some manner, involved in the toxification of pufferfish.

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까치복, *Fugu xanthopterus*의 조직별 독성차이

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부산 시내 어시장에서 구입된 까치복어, *Fugu xanthopterus*의 조직부위별 독성과 특정부위의 독성간 상호관계를 mouse bioassay법에 의하여 비교 검토하였다. 즉, 개체당 전체 독량이 0~36,816 MU로써 개체에 따라 독성차이가 있으며, 간, 난소 그리고 내장의 평균독성은 각각 110.0±25.0, 115.0±33.0 및 73.0±20.3 MU/*g*(평균치±표준편차)이었다. 또한 각 부위별 독성의 빈도순서는 간(88%), 난소(80%), 내장(75%), 정소(71%), 담즙(71%), 껍질(54%), 그리고 근육조직(13%)의 순이었다. 한편 간과 내장, 껍질, 난소조직의 독성은 그 상관계수가 각각 r=0.93, r=0.79 및 r=0.83으로 뚜렷한 상관관계를 나타내었다.