Bull. Korean Fish. Soc. 27(6), 682~689, 1994 韓水誌, 27(6), 682~689, 1994

Toxicity of Several Puffers Collected at a Fish Market of Pusan, Korea

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Ninety-six specimens of nine puffer fishes landed at a fish market of Pusan, Korea were assayed for anatomical distribution of toxicity. The puffers, *Lagocephalus gloveri* ("geommilbog"), *Fugu rubripes rubripes* ("jajubog"), *Fugu rubripes chinesis* ("geomjajubog"), *Lagocephalus wheeleri* ("hinmilbog") and *Arothron firmamentum* ("byeolbog"), were shown to be nontoxic in muscle and skin. However, toxicities in skins of four specimens of *Lagocephalus gloveri* and a specimen of *Arothron firmamentum* were more than 10*MU/g*

In the puffer, *Fugu xanthopterus* ("ggachibog"), the skin showed to be weakly toxic as far as nine specimens out of 27 ones are concerned, and the muscle was nontoxic in all specimens. Meanwhile, it was noted that the puffer, *Fugu vermicularis radiatus* was found to be a toxic species, differing from the toxicity known so far. Their highest toxicities were 3,880, 1,191, 1,115, 219, 289, 5,620 and 753*MU/g* for liver, intestine, skin, muscle, testis, ovary and bile, respectively.

Introduction

Seafood toxins include tetrodotoxin (TTX), paralytic shellfish poison (PSP), ciguatera toxins, scombroid related toxins and diarrhetic shellfish poison (DSP), etc. Especially, TTX, puffer poison, is found in certain puffers. The puffers have worldwide distribution in both tropical and semitropical waters. Thus, it is known that approximately 20 species of puffers inhabit the coast of Korea. The pufferfish also increase in toxicity beginning in September; toxicity reaches its peak just before or during the spawning season in May and June according to a report of National Fisheries Quarantine Station in Korea (1989). There is variability in the toxicity of certain puffer species depending on the geography, season of the year, and sex of the fish. Especially, Onoue *et al.* (1984) reported that the same species caught at the same time of the year from semitropical area are found to be very toxic in their skins and muscles.

As to the distribution of TTX in nature, it was long believed that TTX had been exclusively contained in puffers of the family tetraodontidate. However, some of studies have shown that a wide variety of marine animals contain TTX or related substances in their body (Narita *et al.*, 1981). TTX is also secreted by a crab (Noguchi *et al.*, 1983), a starfish (Narita *et al.*, 1987), a pufferfish (Noguchi *et al.*, 1987) and a ribbon worm (Ali *et al.*, 1990).

Anatomical classification of toxicity in puffers has been generally used the study of Tani (1945). However, it is noted that individual variation of toxicity is observed among the specimens caught at the same time and place according to the reports of other researchers (Kanoh *et al.*, 1985, Kim, 1991 and Hwang *et al.*, 1988). In spite of Puffer poisoning is posing continuously a serious problem in food hygiene, there are not enough data for several species of puffers inhabiting the coasts of Korea depending on species, tissues, locality, and season of collection. Therefore, imported puffers from foreign countries should be examined and controlled strictly.

Under these circumstances, the 96 specimens in the 9 species of Korean puffers were collected at fish markets in Pusan, Korea and the present study was assayed for the anatomical distribution of their toxicities.

Materials and Methods

The following species of puffers were collected at a fish market in Pusan from October 1988 to August 1989: *Lagocephalus gloveri* ("geommilbog"), *Fugu rubripes rubripes* ("jajubog"), *Fugu vermicularis radiatus*("gukmeribog"), *Fugu xanthopterus* ("ggachibog"), *Lagocephalus wheeleri* ("hinmilbog"), *Arothron firmamentum* ("byeolbog"), *Sphoeroides pachygaster* ("mulmilbog"), *Fugu rubripes chinensis* ("geomjajubog") and *Fugu vermicularis porphyreus* ("geombog"). Those specimens were immediately frozen, packed in ice box and transported to our laboratory, and kept frozen at $-20℃$ until used. Each specimen was made to be as half thawing state, and dissected into the muscle, skin, liver, intestine and ovary.

Assay of toxicity

Toxicity was assayed by the method of Ministry of Health and Welfare (1978) of Japan for tetrodotoxin. Briefly, about 1*g* of each tissue was added with 9 volumes of 0.1*N* acetic acid after homogenized and heated for 10*min* in the boiling water bath. The extract thus was injected into a male mouse of ddY strain (18~20*g* body weight) with 1*ml*. The toxicity was calculated by use of dose-death time curve for TTX, and expressed in terms of mouse unit (MU). One mouse unit is defined as the amount of TTX required to kill a mouse within 30 *min* after i.p. injection.

Results and Discussion

Anatomical toxicities for twenty-four specimens of *Lagocephalus gloveri* were shown in Table 1. The mean of total length and body weight was 26.2*cm* and 332*g*, respectively. Most of tissues were revealed to be non-toxic except for skins of six specimens which were non-toxic or weakly toxic ranging from 6 to 19*MU/g*. The puffer, *Lagocephalus glover* examined has been regarded as edible fish judging from their toxicities. However, the toxicity of ovary and liver tissue widely differed depending upon specimen, locality and season of catch (Tani, 1945).

The anatomical distribution of toxicity for the 10 specimens of *Fugu rubripes rubripes* was shown in Table 2. The mean of total length and body weight in these specimens was 23.1*cm* and 320*g*, respectively. The toxicities of all these specimens were non-toxic except for the intestine (6*MU/g*) of one specimen. From these results, *Fugu rubripes rubripes* was judged to be a non-toxic species.

The results of anatomical toxicity on *Fugu vermicularis radiatus* are summarized in Table 3. The mean of total length and body weight was 21.7*cm* and 249*g*, respectively. People generally have a tendency to confound *Fugu vermicularis radiatus* with *Fugu pardalis* because of all much same in color and shape each other. The characteristic pattern of toxin distribution observed on these specimens was exhibited; their highest toxicity scores were 3,880, 1,191, 1,115, 219, 289, 5,620 and 935*MU/g*, in terms of liver, intestine, skin, muscle, testis, ovary and bile, respectively. From the above results, *Fugu vermicularis radiatus* was judged to be weakly or moderately toxic in muscle and skin. However, the distribution pattern of toxin in muscle and testis was all non-toxic, but skin of the species was judged to be toxic by a report of Kanoh *et al.* (1985). Therefore, it is recommended that at least the species may have been prohibited from marketing in Korea, and it must be required to be careful of handling because the toxin of higher toxic tissues may

Table 1. Anatomical distribution of toxicity in *Lagocephalus gloveri* collected at a fish market in Pusan, Korea (October 1988~August 1989)

Specimen No.	Total length (*cm*)	Body weight (*g*)	Toxicity(*MU/g*) Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	Total toxicity (*MU*)
1	26.5	357	ND*	ND	13	ND	-**	-	-	465
2	25.7	256	ND	ND	14	ND	ND	-	-	336
3	26.2	300	ND	ND	19	ND	-	-	-	815
4	25.2	285	ND	ND	ND	ND	ND	-	ND	(0)
5	25.0	285	ND	ND	ND	ND	ND	-	ND	(0)
6	25.5	320	ND	ND	ND	ND	-	ND	-	(0)
7	25.8	330	ND	ND	ND	ND	-	ND	ND	(0)
8	25.6	325	ND	ND	ND	ND	-	ND	-	(0)
9	25.5	328	ND	ND	ND	ND	ND	-	ND	(0)
10	25.0	310	ND	ND	ND	ND	ND	-	ND	(0)
11	25.0	310	ND	ND	ND	ND	-	ND	ND	(0)
12	26.0	340	ND	ND	ND	ND	-	ND	ND	(0)
13	28.8	536	ND	10	6	ND	ND	-	ND	578
14	22.4	230	ND	ND	9	ND	-	-	ND	191
15	23.5	235	ND	ND	10	ND	ND	-	ND	269
16	27.2	365	ND	ND	ND	ND	-	ND	ND	(0)
17	27.5	360	ND	ND	ND	ND	-	ND	ND	(0)
18	26.8	320	ND	ND	ND	ND	-	ND	ND	(0)
19	28.3	380	ND	ND	ND	ND	-	ND	ND	(0)
20	27.0	365	ND	ND	ND	ND	-	ND	ND	(0)
21	27.5	325	ND	ND	ND	ND	ND	-	ND	(0)
22	27.0	380	ND	ND	ND	ND	ND	-	ND	(0)
23	27.2	350	ND	ND	ND	ND	ND	-	ND	(0)
24	27.4	370	ND	ND	ND	ND	ND	-	ND	(0)

*: Not detected
**: Not assayed

Table 2. Anatomical distribution of toxicity in *Fugu rubripes rubripes* collected at a fish market in Pusan, Korea (October 1988~August 1989)

Specimen No.	Total length (*cm*)	Body weight (*g*)	Toxicity(*MU/g*) Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	Total toxicity (*MU*)
1	19.8	200	ND*	ND	ND	ND	-**	-	-	(0)
2	18.5	200	ND	ND	ND	ND	-	-	-	(0)
3	21.5	295	ND	ND	ND	ND	-	-	-	(0)
4	22.2	335	ND	ND	ND	ND	-	-	ND	(0)
5	19.8	180	ND	ND	ND	ND	-	-	ND	(0)
6	22.2	280	ND	ND	ND	ND	-	-	ND	(0)
7	23.8	245	ND	6	ND	ND	ND	-	ND	77
8	21.6	220	ND	ND	ND	ND	-	-	ND	(0)
9	33.2	825	ND	ND	ND	ND	ND	-	ND	(0)
10	28.0	515	ND	ND	ND	ND	ND	-	ND	(0)

*,** : Refer to the footnotes in Table 1.

Table 3. Anatomical distribution of toxicity in *Fugu vermicularis radiatus* collected at a fish market in Pusan, Korea (October 1988~August 1989)

Specimen No.	Total length (*cm*)	Body weight (*g*)	Toxicity(*MU/g*) Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	Total toxicity (*MU*)
1	23.3	264	97	106	111	19	-**	-	-	9,066
2	21.4	220	3,880	645	335	33	-	-	-	122,260
3	16.5	110	12	23	46	11	-	-	-	3,519
4	19.0	150	640	268	85	22	-	-	-	14,519
5	20.5	220	ND*	43	28	20	-	-	-	2,099
6	25.1	390	1,705	785	286	41	-	2,500	753	166,072
7	25.0	320	296	226	260	21	-	1,680	133	39,896
8	24.0	296	3,300	375	1,115	219	-	5,620	935	260,180
9	25.1	410	3,820	382	425	21	-	3,780	-	315,112
10	23.7	320	504	1,191	153	125	-	1,596	-	131,220
11	26.3	400	11	23	25	9	20	-	10	4,876
12	24.5	380	25	233	31	21	-	296	433	30,855
13	19.0	140	508	176	20	12	70	-	-	8,099
14	19.5	140	544	377	62	15	289	-	-	13,218
15	18.5	140	79	21	33	9	-	-	-	2,720
16	16.0	80	10	12	14	8	-	-	-	693

*,** : Refer to footnotes in Table 1.

be transferred to edible tissues, muscle and skin, for freezing or thawing.

The mean of total length and body weight was 29.7*cm* and 517*g*, respectively, as demonstrated in Table 4, for *Fugu xanthopterus* of these 27 specimens. Most muscles were revealed to be non-toxic except for only one specimen (Specimen No. 13). Also, skin of the specimens had a toxic frequency of about 59% with the highest toxicity score of 40 *MU/g*. Their highest toxicity values were 550 (liver), 528 (ovary), 265 (testis), 368 (bile) and 382 (intestine) *MU/g*. The skin, muscle and testis of the puffer, according to the report of Tani (1945), had been known to non-toxic; however, in this study, it was noteworthy that toxic tissues were found depending upon individual variation and time of catch. Also, the highest score of total toxicity was shown to be 53,132*MU/g*.

The toxicity of *Lagocephalus wheeleri, Arothron firmementum, Sphoeroides pachygaster* ("mulmilbog"), *Fugu rubripes chinensis* ("Geombog") and *Fugu vermicularis porphyreus* are shown in Table 5. The shape of *Lagocephalus wheeleri* is similar that of *Lagocephalus gloveri*, but both of them are distinguished by a difference of body color and caudal fin. The mean of total length and body weight was 28.3 *cm* and 428*g*, respectively. Liver, ovary and testis of the puffer were showed to be the highest toxicity score being 12, 73 and 61*MU/g*, respectively.

The mean of total length and body weight of Arothron firmamentum was 30*cm* and 573*g*, respectively. Their highest toxicity score were 57, 18 and 140*MU/g*, in terms of skin, intestine and bile, respectively, but there was non-toxic in muscle and testis. Especially, one of the specimens was 3,797 *MU/g* in the highest value of total toxicity.

In spite of unedible fish by the classified table (National Fisheries Quarantine Station in Korea, 1989), the puffer, *Arothron firmentum*, has been on the market. The muscle and liver of all specimens were non-toxic, while the skin of 3 specimens and the intestine of 2 specimens were toxic, and the

Table 4. Anatomical distribution of toxicity in *Fugu xanthopterus* collected at at a fish market in Pusan, Korea (October 1988~August 1989)

Specimen No.	Total length (*cm*)	Body weight (*g*)	Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	Total toxicity (*MU*)
			Toxicity (*MU/g*)							
1	26.2	358	ND*	8	ND	ND	-**	-	-	100
2	25.7	330	220	52	11	7	-	-	-	9,370
3	27.3	400	142	74	14	ND	-	-	-	5,589
4	28.5	475	233	42	6	ND	-	83	12	12,251
5	29.0	480	473	216	7	ND	-	-	-	24,065
6	30.5	565	550	227	29	ND	-	528	28	33,460
7	31.6	620	ND	ND	ND	ND	-	23	ND	182
8	31.2	630	19	14	ND	ND	-	313	15	5,397
9	28.7	480	ND	ND	ND	ND	ND	-	ND	(0)
10	30.5	710	21	14	ND	ND	-	210	ND	8,120
11	29.5	640	ND	ND	ND	ND	ND	-	ND	(0)
12	31.0	680	23	16	6	-	-	263	80	7,903
13	25.5	340	241	31	31	20	265	-	70	15,446
14	25.4	360	45	11	8	ND	ND	-	7	1,335
15	24.5	340	ND	16	22	ND	27	-	ND	1,107
16	32.0	630	ND	6	7	ND	-	68	7	6,912
17	32.4	620	13	17	11	ND	-	311	23	19,309
18	30.8	690	383	382	11	ND	-	488	118	53,132
19	33.5	570	6	6	8	ND	-	24	8	1,260
20	32.0	550	21	6	6	ND	ND	-	13	1,531
21	29.0	390	ND	ND	ND	ND	ND	-	-	(0)
22	30.3	470	ND	ND	ND	ND	-	ND	ND	(0)
23	29.2	500	ND	ND	ND	ND	ND	-	ND	(0)
24	29.7	450	ND	ND	ND	ND	ND	-	ND	(0)
25	33.2	490	ND	6	ND	ND	ND	ND	6	178
26	32.7	570	95	157	40	ND	48	-	117	10,292
27	32.8	620	517	106	19	ND	163	-	368	24,387

*,** : Refer to footnotes in Table 1.

bile of only one specimen was toxic. According to experimental results, the toxicity scores of the puffer *Arothron firmentum* were clearly lower than those of any other tissues in puffer, *Fugu xanthoperus*. Therefore, authors sincerely suggest that *Arothron firmamentum* should be reclassified for edible or unedible fish.

In case of *Fugu rubripes chinensis*, the mean of total length and body weight was 25.6*cm* and 360*g*, respectively. All tissues were found to have non-toxic except for only testis with the highest toxicity score of 45*MU/g*. Also, all tissues of these puffers were non-toxic in *Fugu vermicularis porphyreus* and *Sphoeroides pachygaster* from the data given.

Table 5. Anatomical distribution of toxicity in other puffers collected at a fish market in Pusan, Korea (October 1988~August 1989)

Specimen No.	Total length (*cm*)	Body weight (*g*)	Toxicity (*MU/g*) Liver	Intestine	Skin	Muscle	Testis	Ovary	Bile	Total toxicity (*MU*)
Lagocephalus wheeleri										
1	29.0	478	12	8	ND*	ND	-**	73	6	585
2	28.4	415	ND	7	ND	ND	20	-	ND	191
3	27.6	390	8	ND	ND	ND	61	-	ND	485
Arothron firmementum										
1	28.4	450	ND	6	57	ND	-	-	140	3,797
2	31.5	623	ND	18	5	ND	-	-	ND	1,490
3	31.2	625	ND	ND	ND	ND	-	-	ND	(0)
4	31.9	676	ND	ND	ND	ND	-	-	ND	(0)
5	30.5	625	ND	ND	ND	ND	-	-	ND	(0)
6	26.5	440	ND	ND	7	ND	-	-	ND	463
Sphoeroides pachygaster										
1	22.7	400	ND	ND	ND	ND	ND	-	ND	(0)
Fugu rubripes chinensis										
1	27.0	420	ND	ND	ND	ND	45	-	ND	41
2	26.2	350	ND	ND	ND	ND	ND	-	ND	(0)
3	23.8	320	ND	ND	ND	ND	ND	-	ND	(0)
4	26.5	350	ND	ND	ND	ND	13	-	7	20
Fugu vermicularis porphyreus										
1	21.0	225	ND	ND	ND	ND	-	-	ND	(0)
2	21.3	220	ND	ND	ND	ND	-	-	ND	(0)
3	18.2	140	ND	ND	ND	ND	-	-	ND	(0)
4	20.5	220	ND	ND	ND	ND	ND	-	-	(0)
5	21.4	220	ND	ND	ND	ND	ND	-	-	(0)

*,** : Refer to footnotes in Table 1.

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Received October 7, 1994
Accepted November 5, 1994

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부산 시중에서 판매되고 있는 복어류의 독성

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국내에서 시판되고 있는 독성이 알려져 있지 않은 복어류에 대한 검토 및 현재까지 식용 또는 비식용으로 분류되어 있는 일부 복어류의 독성에 대한 재검토와 유독 복어류의 출현을 감시할 수 있는 정기적이며 지속적인 연구 자료를 축적할 목적으로 부산 시중에서 구입한 9종류의 복어류 96개체를 시료로 하여 그 종류별, 조직 부위별 독성을 재검토하였다. 검밀복 4개체 및 별복 1개체의 껍질은 독성치가 10*MU/g* 이상으로 검출되었으나, 검밀복과 별복의 나머지 개체 및 자주복, 검자주복, 검복, 흰 밀복의 경우는 식용으로 하는 껍질 및 근육이 무독하였다. 까치복의 경우는 27개체 중 9개체의 껍질(최고독력, 40*MU/g*)과 1개체의 근육(10*MU/g*)에서 약독의 독성치가 검출되었으나, 그 이외의 개체 및 근육은 무독하였다. 간장, 내장 및 난소 등에서는 최고 독력이 각각 550*MU/g*, 382*MU/g* 및 528 *MU/g* 으로 독성이 강하여 조리 취급시 주의가 요망된다. 국매리복의 경우는 근육에서 약독 내지 강독(최고독력, 219*MU/g*), 껍질에서 약독 내지 맹독(최고독력, 1,115*MU/g*)의 독성치가 검출되었다. 특히, 간장, 내장 및 난소에서는 최고독력이 각각, 3,820*MU/g*, 1,191 *MU/g* 및 5,620*MU/g*의 맹독의 독성치가 검출되어 식용 어종으로 분류하는 것은 문제점이 있어 충분한 재검토가 요망된다.