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HEAVY METAL CONTENTS IN TAIWAN'S CULTURED FISH

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ABSTRACT

S. S. Jeng and Y. W. Huang (1973). *Heavy metal contents in Taiwan's cultured fish.* Bull. Inst. Zool., Academia Sinica, **12**(2): 79-85. In order to find out whether fish around the waters of Taiwan are safe in heavy metal contents, 119 fish of tilapia, common carp, grass carp, silver carp and milkfish, and 240 oysters from the fish pond were analyzed for concentrations of cadmium, copper, lead, mercury, nickel and zinc. Most of the fish surveyed have a concentration of mercury less than 0.08 ppm, and none of them over 0.2 ppm. The lead level of fish muscle is 0.1 ppm, and 0.5 ppm for oyster. The cadmium in fish muscle and oyster is 0.02 ppm and 0.2 ppm, respectively. The contents of copper, zinc and nickel studied are all at ordinary levels. The general conclusion is that the heavy metal concentrations of Taiwan's cultured fish do not appear to constitute a hazard for consumers.

Since eating the mercury and cadmium contaminated fish caused "Minamata" and "Itai-Itai" diseases in Japan[1,2], suspicion has been aroused that toxic metals contamination may be widespread. The people in Taiwan consume much fish in their diet, whether the fish sold in the market is polluted by heavy metals has attracted a great attention. On this island, various kinds of fish are reared in diverse fish ponds and along coastal areas. Analyzing the heavy metal contents of these cultured fish may give a general idea of fish contamination, and it may also be a good index to know the extent of water pollution. This paper reports a comprehensive investigation of cadmium, copper, lead, mercury, nickel and zinc contents of tilapia, common carp, grass carp, silver carp, milkfish and oyster.

MATERIALS AND METHODS

Materials

In order to find out the effect of different water sources on the contents of heavy metals, fish were caught directly from diverse fish ponds. The sampling stations, their locations and the nature of culture waters are shown in Table 1 and Fig. 1, respectively. These stations are typical fish ponds.

Preliminary treatment

Fish caught were sent to the laboratory in a box containing ice. After measuring total length and total weight, the fish were eviscerated. The muscles of the same species of fish were grouped and treated as one sample. In case of large fish, three transverse slices, 1 inch thick: one slice from just back of pectoral fins, one slice halfway between first slice and the vent, and one slice

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TABLE 1
The sampling stations, types of fish ponds, and the fish caught for analyses. Locations of sampling stations are shown in Fig. 1.

Sampling station	Fish ponds	Fish caught
(1) Yunling Pref. (雲林縣 三條崙)	shallow sea culture	oyster
(2) Yunlin Pref. (雲林縣 金湖)	shallow sea culture	oyster
(3) Chiayi Pref. (嘉義縣 東石)	shallow sea culture	oyster
(4) Chiayi Pref. (嘉義縣 布袋)	shallow sea culture	oyster
(5) Changhua Pref. (彰化縣 竹塘)	paddy field	tilapia, silver carp, grass carp, common carp
(6) Tainan Pref. (臺南縣 學甲)	fresh water pond	tilapia
(7) Tainan Pref. (烏山頭淡水養殖中心)	reservoir lake	tilapia, silver carp, grass carp
(8) Tainan City. (臺南市 南興塭)	fresh water pond	tilapia, common carp
(9) Tainan City. (臺南水試所)	brackish water pond fresh water pond	tilapia, milkfish silver carp, grass carp, common carp

just back of the vent, were cut to respresent one fish as suggested by AOAC[3]. Viscera of the same species of fish were also combined as one sample. Likewise the edible portions of the oyster were put together as one sample. Two analyses were made for each sample.

Ashing method and determinating the concentrations of heavy metals

Mercury content was determined by the flameless atomic spectrophotometry with a Colemen MAS mercury analyzer[4]. Cd, Cu, Ni, Pb and Zn were all measured with a Varian Model 1000 type atomic absorption spectrophotometer. Zinc was determined by AOAC method[5]. For analyses of Cd, Cu, Pb and Ni, 7 g of sample was wet-ashed by H_2SO_4 and HNO_3[5], by using a 50 ml Kjeldahl flask with the 50 ml mark positioned at the neck of the flask. After ashing, the heavy metals were extracted with APDC (ammonium pyrrolidine-N-dithiocarbamate)-MIBK (methyl isobutyl ketone) by a modification of the

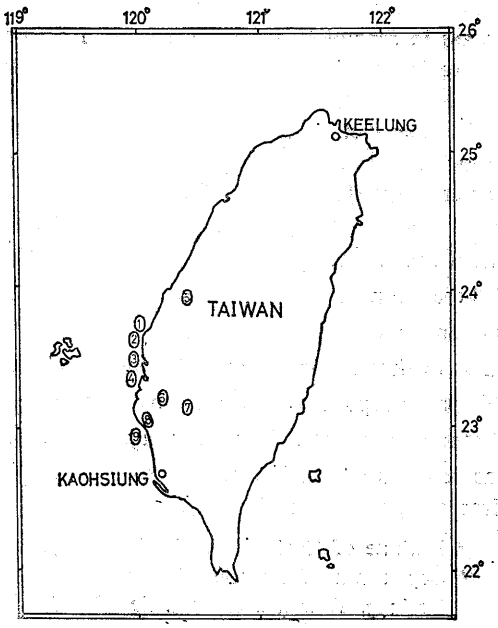

Fig. 1. Locations of sampling stations.

TABLE 2

Heavy metal contents of Taiwan's cultured oyster, *Crassostrea gigas* (Thunberg).

Sampling station	Date of catch	No. of oyster	Mean wt. (g)	μg/g wet tissue					
				Cd	Cu	Hg	Ni	Pb	Zn
(1)	May 17, 1973	4	1.80	0.15	27.5		0.3	0.3	78
	Jul. 17, 1973	15	0.97	0.19	26.1	0.04	0.1	0.2	95
	Aug. 17, 1973	9	1.78	0.11	6.6	0.04	0.3	0.8	
	Sep. 14, 1973	60	1.62	0.21				0.8	33
(2)	May 17, 1973	2	3.05	0.27	28.1		0.3	0.4	68
	Jul. 17, 1973	13	1.14	0.14	27.0	0.04	0.4	0.3	61
	Aug. 17, 1973	8	1.76	0.09	23.8	<0.01	0.2	0.5	
	Sep. 14, 1973	30	0.93	0.25				0.7	65
(3)	May 17, 1973	2	3.50	0.19	33.4		0.1	0.6	23
	Jul. 17, 1973	6	2.44	0.13	18.7	0.04	0.3	0.1	34
	Aug. 17, 1973	9	1.44	0.10	11.4	0.03	0.3	0.1	
	Sep. 14, 1973	30	1.76	0.22				0.6	37
(4)	May 1, 1973	15	2.27	0.14	37.9	<0.01	0.6	0.2	77
	Aug. 17, 1973	7	2.16	0.13	12.9	0.01	0.2	0.1	
	Sep. 14, 1973	30	1.55	0.21				0.5	33

TABLE 3

Heavy metal concentrations (μg/g wet tissue) of Taiwan's cultured tilapia, *Tilapia mossambica* Peters.

Sampling station		(5)	(6)	(7)	(8)	(9)
Date of catch		Apr. 16, 1973	Apr. 16, 1973	Apr. 16, 1973	Apr. 16, 1973	Apr. 16, 1973
No. of fish		16	12	11	12	16
Total length (cm)		16.1 (14.0-18.5)	18.8 (17.5-20.0)	15.9 (12.5-19.0)	17.1 (15.2-19.0)	12.1 (9.6-15.1)
Total weight (g)		81 (60-108)	110 (99-126)	83 (42-121)	90 (50-139)	34 (20-55)
Cd	muscle	0.01	0.10	0.04	0.04	0.01
	viscera	0.03	0.19	0.07	0.07	0.15
Cu	muscle	0.7	1.6	0.7	0.5	1.0
	viscera	8.1	6.1	8.5	3.0	6.5
Hg	muscle	0.08	0.16	0.01		0.07
	viscera	0.09	0.09	0.01		0.04
Ni	muscle	0.1	0.6	0.2	0.4	0.5
	viscera	1.7	4.6	1.3	3.0	7.2
Pb	muscle	0.1		0.1	<0.1	<0.1
	viscera	0.2		0.8	0.2	1.8
Zn	muscle	11	6			18
	viscera		29			40

method of Tsutsumi[6]. Ammonium hydroxide was added to the ashed solution to adjust pH to 3 with BPB as indicator. Saturated ammonium sulfate solution was added to make the final volume of 50 ml. Two milliliter of 2% APDC was added and shaken well. After standing for 5 minutes, the sample solution was extracted with 5.0 ml MIBK. Since MIBK solution was the top layer in the Kjeldahl flask, it could be used to measure the atomic absorbance of Cd, Cu, Ni and Pb directly. The contents of these elements in the sample were then determined from standard curves. The sensitivity of the method was 0.01 ppm of Hg, 0.1 ppm of Ni, 0.01 ppm of Pb, 0.01 ppm of Zn in fish on a fresh weight basis.

RESULTS AND DISCUSSION

The results of the analyses of heavy metal concentrations of Taiwan's cultured fish are shown in Tables 2 to 5, and the mean values of these 119 fish and 240 oysters are represented in Table 6. Based on these data, the general conclusion is that the heavy metal concentrations in Taiwan's cultured fish investigated here do not appear to constitute a health hazard to the consumers.

FAO[7] reported mercury and lead is the most toxic of all trace elements. Most of the fish surveyed here had a concentration of mercury less than 0.08 ppm, and none over 0.2 ppm. In unpolluted areas, fish has a concentration of less than 0.05 ppm in Sweden, less than 0.1 ppm in Italy, 0.1 ppm in Japan[8]. Therefore, the fish in Taiwan do not seem to be polluted by mercury.

The Canadian Food and Drug Directorate has set tolerance of 10 ppm for lead[9]. The muscle of Taiwan's cultured fish contain a lead

TABLE 4

Heavy metal concentrations (μg/g wet tissue) of Taiwan's cultured common carp, *Cyprinus capio* Linnaeus, and grass carp, *Ctenopharyngodon idellus* (Cuvier and Valenciennes).

Sampling station		Common carp			grass carp	
		(5)	(8)	(9)	(7)	(9)
Date of catch		Sep. 21, 1973	Sep. 21, 1973	Sep. 21, 1973	Sep. 21, 1973	Sep. 21, 1973
No. of fish		7	6	3	5	6
Total length (cm)		14.8 (12.5-17.0)	21.9 (21.1-22.8)	26.2 (23.8-29.4)	19.1 (18.5-20.0)	50.0 (41.7-50.1)
Total weight		49 (36-62)	145 (100-195)	36 (233-514)	980 (81-115)	1130 (918-1350)
Cd	muscle	0.01	0.01	0.01	0.03	0.01
	viscera	0.04	0.03	0.01	0.11	0.01
Cu	muscle	2.7	0.9	1.2	1.3	0.9
	viscera	15.0	4.8	1.4	2.6	2.1
Hg	muscle	0.18	0.08		0.07	0.01
	viscera		0.04	0.02	0.01	0.01
Ni	muscle	0.1	0.1	0.1	1.8	0.1
	viscera	0.9	0.1	0.1	0.1	0.1
Pb	muscle	0.1	0.2	0.1	0.4	0.1
	viscera	0.1	0.6	0.1	1.2	0.1
Zn	muscle	57	92	26	10	22
	viscera	188	585	174	8	21

TABLE 5
Heavy metal concentrations (μg/g wet tissue) of Taiwan's cultured silver carp, *Hypophthalmichthys molitrix* (Cuvier and Valenciennes), and milkfish, *Chanos chanos* (Forskal).

Sampling station		Silver carp			milkfish
		(5)	(7)	(9)	(9)
Date of catch		Sep. 21, 1973	Sep. 21, 1973	Sep. 21, 1973	Sep. 21, 1973
No. of fish		7	6	6	6
Total length (cm)		31.7 (25.5-34.8)	22.2 (20.0-25.5)	44.6 (42.5-45.5)	32.5 (31.4-34.2)
Total weight (g)		330 (141-464)	105 (86-126)	990 (880-1200)	289 (255-338)
Cd	muscle	0.01	0.02	0.01	0.01
	viscera		0.03	0.01	0.01
Cu	muscle	0.7	7.4	7.0	0.5
	viscera		4.5	2.3	2.9
Hg	muscle	0.06	0.17	0.07	0.01
	viscera		0.04	0.04	0.20
Ni	muscle	0.1	0.2	0.1	0.1
	viscera		2.1	1.0	0.4
Pb	muscle	0.1	0.1	0.1	0.1
	viscera		0.1	0.1	0.1
Zn	muscle	6	31	15	10
	viscera		64	42	16

TABLE 6
Heavy metal concentrations (μg/g wet tissue) of Taiwan's cultured fish.

		Cd	Cu	Hg	Ni	Pb	
Fish	muscle	0.02 (0.00-0.10)	1.4 (0.5-1.6)	0.08 (0.00-0.17)	0.3 (0.0-1.8)	0.1 (0.0-0.4)	25 (6-92)
	viscera	0.07 (0.00-0.15)	5.9 (1.4-15.0)	0.08 (0.00-0.09)	2.4 (0.1-7.2)	0.5 (0.0-2.0)	46* (16-64)
Oyster	edible portion	0.19 (0.10-0.27)	23.3 (6.6-37.9)	0.03 (0.00-0.04)	0.3 (0.1-0.6)	0.5 (0.1-0.8)	49 (23-78)

* Not including those values of common carps which had a level of 170-585 ppm.

level of 0.1 ppm and the viscera of fish and the edible portion of oyster are both at 0.5 ppm level. The values are far bellow the permissible level.

Cadmium is one of the most harmful heavy metals as it concentrates in the liver, kidney and certain other organs of animals and human[10]. The fish investigated here did show a higher concentration of cadmium in fish viscera than in muscle. But these concentrations are low compared to those of ordinary meats and sea food[11]. Oysters showed a cadmium level of 0.2 ppm which is 10 times higher than that of fish muscles. But all these concentration are lower than the permissible level of 1.0 ppm set by Japanese Government[12].

The concentrations of less dangerous heavy metals, e. g., copper, zinc and nickel of fish investigated here were all at ordinary levels, except that the viscera of common carp showed a high zinc concentration of 174-585 ppm. Since common carp from paddy field, fresh water pond and brackish water pond all had a high content of zinc (Table 4) in the viscera, it is presumed that this concentration of zinc is nature to the common carp. Which specific tissue is responsible for this concentration of zinc and the reason for this phenomenon are being studied now.

Besides cadmium, oyster also showed a higher level of copper, lead and zinc than fish, this agreeing with other reports[13,14] that bivalve molluscs very easily absorb heavy metals from the environment.

Fish from different waters seem have the same levels of heavy metals. This is especially true of tilapia which were captured from five diverse fish ponds (Table 3). Because all fish analyzed here had ordinary levels of heavy metals, hence no correlation could be found between fish weight and heavy metal contents.

Many external factors influence the toxicity and absorption of metals by fish. These include the nature and concentration of the metal, its valence, the form of the metal in water, the associated anion, pH, time of exposure, volume of water, stationary or moving water, temperature, dissolved oxygen, and the nature and condition of the fish[15]. There are few stationary waters like the bay or sound around Taiwan, this may be one of the reasons making it difficult for the aquatic organisms and animals to accumulate heavy metals.

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臺灣養殖魚貝類之重金屬含量

鄭森雄　黃耀文

為知臺灣養殖魚貝類是否受重金屬之污染，乃自各地魚塭購買 119 尾吳郭魚、鯉魚、草魚、鰱魚、虱目魚，及 240 隻牡蠣分析其中之鎘、銅、鉛、汞、鎳及鋅之含量。由實驗結果知臺灣養殖魚貝類之重金屬含量皆在普通範圍內，不致對消費者構成威脅。