International Food Research Journal 21(6): 2109-2113 (2014)
Journal homepage: *http://www.ifrj.upm.edu.my*

Fresh water aquaculture fish consumption in Malaysia and heavy metals risk exposure to consumers

[1*]Ibrahim, A. B., [2]Mohd Khan, A., [2]Norrakiah, A.S. and [1]Intan Fazleen, Z.

[1]*Department of Nutrition Sciences, International Islamic University Malaysia, 25200 Kuantan, Malaysia*
[2]*School of Chemical Sciences and Food Technology, Faculty of Science and Technology, National University of Malaysia, 43650 UKM Bangi, Malaysia*

Article history

Received: 31 January 2014
Received in revised form: 7 April 2014
Accepted: 16 April 2014

Keywords

Fresh water
Aquaculture fish
Fish consumption
Risk exposure
Heavy metal residues

Abstract

This study aimed to determine the amount of the fish (*Oreachromi* sp, *Clarias* sp. and *Pangasius sutchii*) consumption in Malaysia; the quantity of heavy metal residues (arsenic, cadmium, mercury and plumbum) in the fish and the level of the risk exposure. About 1440 respondents from six main production districts were randomly interviewed and the body weight of the respondents was also measured. A total of 240 ready to eat fish from food premises were also stratified randomly sampled where each sample was weighted to determine the average weight of one serving unit sold at food premises. The heavy metal residues were analyzed using Inductively Coupled Plasma–Optical Emission Spectrometer (ICP-OES) Optima 4300 DV (German). The level of heavy metals risk exposure was calculated as the percentage value of 'Provisional Tolerable Weekly Intakes' (PTWI) and recalculated using computer programme @Risk 4.5 Excel (Palisade, USA). The result showed that 60.3% of the respondents consumed the fish. The level of heavy metal risk exposures were calculated as very low i.e. 0.14% (As), 0.31% (Cd), 0.09% (Hg) and 0.78% (Pb).

Introduction

Human being consumes fish since ancient time due to their high nutritional value. Fish contain higher protein value compare to meat (Smolin and Grosvenor, 2003). Fish contain 55-84% water, 15-24% protein, 0.1-22% fat and 0.1-0.3% carbohydrate (Kumar, 2005). Protein and other proximate values are varied in fish depend on species, size, age, capture area, type of aquaculture and seasons. The existing of high polyunsaturated fatty acids (PUFA) omega three ϖ-3(n-3) and omega six ϖ-6(n-6) in fish are good for human health (Simopoulos, 2004; Sidhu, 2003). Fresh water fish contain 12-25% PUFA relatively to their total fat but seafish has higher PUFA compare to fresh water fish. Fish contain vitamin A, D, B1, B2, B6, B12, Pantothenic acid (PA), Folic acid and Niacin beside the existing of 0.8-2% mineral content (Kumar, 2005). The low level of carbohydrate and fat content in fish make them popular diet choices among consumers who want to reduce their body weight.

Without denying good nutritional value in fish, there are also some chemical contaminants in fish that are hazardous to human being especially involving fresh water aquaculture fish. One of them is heavy metal residue (Heever and Frey, 1996; Iqbal *et al.*, 2002). It is important to know the level of the heavy metal risk exposure based on the fish consumption especially for monitoring purposes by government agencies to reduce the health impacts.

The rate of fish consumption per capita in Malaysia in 2003 was about 51.4 kg per year with the average increment of about 1.6% yearly since the year 2000 as reported by Ministry of Agriculture Malaysia in 2004. In 2004, Ministry of Agriculture Malaysia stated that the rate of meat consumption percapita in this country in 2002 was about 5.41 kg per year. It showed that the fish consumption in Malaysia was far more than the meat consumption.

The objectives of this study were to determine the amount of the fresh water aquaculture fish consumption [specifically red tilapia (*Oreachromi* sp), keli (*Clarias* sp.) and patin (*Pangasius sutchii*)] in Malaysia, to measure the quantity of heavy metal residues (namely arsenic, cadmium, mercury and plumbum) in the fish and to calculate the level of heavy metals risk exposure to the consumers.

Material and Methods

Interview of the consumers and body weight measurement

About 1440 respondents from six main production districts of fresh water aquaculture fish in Malaysia (Kuantan, Pekan, Temerloh, Jerantut, Hulu Langat and Kinta) were interviewed. Respondents were simple randomly chosen at restaurants, food stalls, night markets' food stalls, hospitals and

*Corresponding author.
Email: *iab@iium.edu.my*
Tel: 09 5715308

health clinics. The interviews were done based on the specific questionnaire which cover information of respondents' background, whether they consume fresh water aquaculture fish or not, the number of fresh water aquaculture fish that they eat and either they know the risk of consuming fresh water aquaculture fish or not. The body weight of the respondents was also measured as these data will be used to calculate the level of heavy metals risk exposure.

Statistical analysis

All data gained from the interviews and body weight measurements were statistically analyzed using the SPSS Windows program version 12.0.

Analysis of heavy metal residue in ready to eat fresh water aquaculture fish

A total of 240 ready to eat fresh water aquaculture fish from restaurants, food stalls and night markets' food stalls at six main production districts in Malaysia were also stratified randomly sampled according to the type of fish and the type of aquaculture system. The samples were then sent to the laboratory and were kept in the refrigerator until the analysis begins. The sample was defrosted at room temperature (25-27^{o}C) prior to the analysis. About 5 g of the fish meat was weight using electronic weighing scale (A&D HR-200, Japan). The fish meat was then put in the thermoplastic tube (Perflouralkohol, Dupont Corp.) for the digestion process. About 5 ml liquid of nitric acid (HNO_3 65%) and 3 ml liquid of hydrogen peroxide (H_2O_2 30%) were added to the tube before setting it in the rotor digestor (MDR-300, Milestone, Italy). The rotor digestor was then put in a high performance microwave (MLS-1200 Mega: 2400 Hz, Milestone, Italy) and the digestion process was done according to the microwave manual (Anon, 1994). The digested sample was cooled automatically by the microwave. Then, the digested sample was transferred into 100 ml polyethylene bottle and 10 ml liquid of hydrochloric acid (HCl) were added to the bottle to digest all inorganic and oxide salt which had formed during the digestion process. The anion water was then added to the bottle up to 100 ml and the sample was kept in cool temperature (4^{o}C) until the analysis of heavy metal residues starts. All glass ware used in the digestion process were non-silicate and all acid reagents used were purely analytical grade.

Analysis of heavy metal residues were performed using Inductively Coupled Plasma–Optical Emission Spectrometer (ICP-OES) (Optima 4300 DV, German) where the source of light was from argon plasma. For an analysis of arsenic, cadmium, mercury and plumbum the concentration of standard solutions used were at 0.1, 0.3, 0.5 and 1.0 ppm, respectively. The samples were injected automatically to ICP-OES using autosampler AS-93 plus design and the concentration of heavy metal residue in the sample was calculated using the formula: (ICP reading x 100) divided by the weight of the sample. The maximum limit of heavy metal residues in the fish sample to be considered as high risk were referred to Malaysia's Food Act (Food Act 1983 and Food Regulation 1985).

Measurement of fish consumption and heavy metals risk exposure

The weight of the fish samples for heavy metal analysis was used to determine the average weight of one serving unit of ready to eat fresh water aquaculture fish sold at the food premises. The weight were then multiply by the average portion of the fish serving units eaten by consumer per meal to be the average weight of ready to eat fresh water aquaculture fish eaten by consumer per meal as the formula below:

The average weight of one serving unit of ready to eat fresh water aquaculture fish sold at the food premises X The average portion of the fish serving unit eaten by consumer per meal = The average weight of ready to eat fresh water aquaculture fish eaten by consumer per meal.

The average portion of the fish serving unit eaten by consumers was calculated from the respond of the consumers in the questionnaires. The average serving unit of ready to eat fresh water aquaculture fish eaten by consumer per day and per week were also calculated from the questionnaires. Thus the average amount (weight) of ready to eat fresh water aquaculture fish eaten by consumer per day or per week were calculated using the formula below:

The average amount of ready to eat fresh water aquaculture fish eaten by consumer per day / week = The average weight of ready to eat fresh water aquaculture fish eaten by consumer per meal X The number of meal per day or per week that contain fresh water aquaculture fish

The level of heavy metals risk exposure to the consumers was then calculated according to the below formula:

Heavy metals risk exposure = The average weight of the fresh water aquaculture fish eaten by consumer X The average quantity of heavy metal residu in the fish

The heavy metals risk exposure per week was divided by the average body weight of the consumer to get the value of 'Provisional Tolerable Weekly Intakes' (PTWI). It was then compared (in term of percentage) to the PTWI standards as stated in Food Act (1983) to determine the level of the risk. The calculation of the risk exposure and the level of the risk also recalculated using computer programme @ Risk 4.5 Excel (Palisade, USA).

Results and Discussion

Consumers' background and their body weight measurement

About 868 (60.3%) respondents had responded that they consume fresh water aquaculture fish. Table 1 shows the background of the respondents from six main production districts of fresh water aquaculture fish in Malaysia where they consist of the wide range of races, education levels and age. It means that Malaysian consumers from different background (especially Malay races) have started to accept fresh water aquaculture fish as the alternative to sea fish in their meal. Aquaculture industries in Malaysia were reported in Perangkaan Perikanan Tahunan 2007 to improve drastically after 1998 (after the launching of the third National Agriculture Policy) where the aquaculture production increase from 8-13% yearly.

From the consumers' body weight measurement, it was showed that the average body weight of the respondents was 65.3 kg. The detail consumers' body weight measurement according to the type of the fish that the consumer eats and recalculated using computer programme @Risk 4.5 Excel was showed in Table 2. The consumers' body weight data were then used in the calculation of heavy metals risk exposure. The interviews also showed that about 721 (83.1%) consumers were did not know the health risk of consuming fresh water aquaculture fish while 22 (57.9%) respondents out of 38 respondents who know the risk got their information from internet, books and newspapers.

Analysis of heavy metal residue

Analysis of heavy metal residues showed that all samples of ready to eat fresh water aquaculture fish which were sampled from food premises have the quantity far below the maximum limit allowed in fish by Malaysia Food Act 1983. That means the level of health risk of consuming fresh water aquaculture fish in Malaysia was very low. The average quantity of each heavy metal residues in the samples according to type of fish, aquaculture system and food premises were showed in Table 3, 4 and 5, respectively.

All quantities of heavy metal residues detected in the samples had no significant different at $p < 0.05$ wheather according to the type of fish, aquaculture system or food premises. The food which has been identified to have contaminants but the contaminants are below the maximum limit as allowed by the specific statndard are safe to consume by human being (Ferenc, 2000). In other research, Iman *et al.* (2013) found that fresh water aquaculture fish collected from Egyptian tilapia farms contain high residues of heavy metals. Tarek (2011) also found high contamination of heavy metals residues in fresh water aquaculture fish.

Table 1. Consumers' background

Parameters	n	Proportion (%)
Districts		
Kuantan	138	15.9
Pekan	143	16.5
Temerloh	158	18.2
Jerantut	158	18.2
Hulu Langat	134	15.4
Kinta	137	15.8
Sex		
Men	465	53.6
Women	403	46.4
Marital Status		
Married	614	70.7
Single	254	29.3
Race		
Malay	583	67.2
Chinese	216	24.9
Indian	69	7.6
Education Level		
Not Yet School	25	2.9
Primary School	56	6.5
Secondary School	657	75.7
University Level	130	15.0
Age Group (years)		
<15	30	3.5
15-19	103	11.9
20-40	542	62.4
40-55	140	16.1
>55	53	6.1

Table 2. Respondents' body weight according to the type of fresh water aquaculture fish and recalculated using computer programme@Risk 4.5 Excel

	Respondents' body weight (kg)				Average value of respondents' body weight recounted using computer programme @Risk 4.5 Excel
Type of fish consumed	Average Weight	Standard Deviation	Lower weight	Upper weight	
Red *tilapia*	65.2	11.0	25	102	65.21
Keli	65.1	11.0	25	102	65.13
Patin	64.9	10.7	25	89	64.57
Average	65.3	10.6	25	102	65.30

Table 3. Average quantity of heavy metal residues in ready to eat fresh water aquaculture fish according to the type of fish

Fish Samples	Arsenic (ppb)	Cadmium (ppb)	Mercury (ppb)	Plumbum (ppb)
Red *tilapia* (n=90)	10.1[a]	9.7[a]	2.3[a]	89.2[a]
keli (n=60)	10.0[a]	9.9[a]	2.3[a]	89.4[a]
patin (n=90)	10.1[a]	9.9[a]	2.4[a]	89.5[a]

Indicator : [a] mean the value (through column) had no significant different at $p < 0.05$

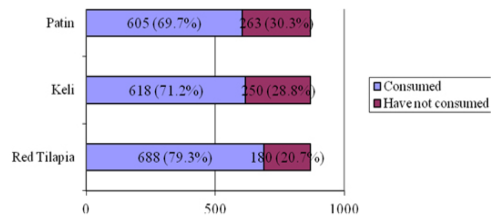

Figure 1. The proportion of respondents who consumed and have not consumed fresh water aquaculture fish according to the type of fish

The consumption of fresh water aquaculture fish

Figure 1 shows the proportion of respondents who eat fresh water aquaculture fish according to the type of fish where tilapia were the most popular aquaculture fish among consumers in Malaysia. Red tilapia were accepted by consumers in Malaysia because of their attractive colour and have good quality of the meat (Kiat, 1988). Sara *et al.* (2013) said aquaculture fish is important as an alternative means of supplying the predicted shortfall of fisheries and other aquatic products. Table 6 shows the average weight of one

Table 4. Average quantity of heavy metals residues in ready to eat fresh water aquaculture fish according to the type of aquaculture systems

Fish Samples	Arsenic (ppb)	Cadmium (ppb)	Mercury (ppb)	Plumbum (ppb)
Earth pond (n=90)	10.1[a]	9.8[a]	2.3[a]	89.2[a]
River net cages (n=60)	10.1[a]	9.9[a]	2.4[a]	89.3[a]
Ex-mining pool (n=90)	10.0[a]	9.9[a]	2.4[a]	89.6[a]

Indicator : [a] mean the value (through column) had no significant different at $p < 0.05$

Table 5. Average quantity of heavy metals residues in ready to eat fresh water aquaculture fish according to the type of food premises

Fish Samples	Residue As (ppb)	Residue Cd (ppb)	Residue Hg (ppb)	Residue Pb (ppb)
Restorants (n=90)	10.3[a]	9.7[a]	1.6[a]	91.5[a]
Food stalls (n=60)	10.1[a]	9.4[a]	1.9[b]	90.7[a]
Night markets (n=90)	9.8[a]	10.3[b]	3.4[c]	85.9[b]

Indicator : [a] mean the value (through column) had no significant different at $p < 0.05$

Table 6. The average weight of one serving unit of ready to eat fresh water aquaculture fish sold at the food premises

Ready to eat fresh water aquaculture fish	Aquaculture system	Average weight (g)	Standard deviation (g)
Red *tilapia*	Earth pond (n=15)	76.9	4.7
	River net cages (n=15)	75.0	8.1
	Ex-mining pool (n=15)	74.6	7.5
Total of red *tilapia* (n=45)		75.5[a]	6.8
keli	Earth pond (n=15)	105.0	8.6
	River net cages (n=15)	105.7	10.2
Total of *keli* (n=30)		105.4[b]	9.3
patin	Earth pond (n=15)	201.6	26.8
	River net cages (n=15)	190.6	35.7
	Ex-mining pool (n=15)	192.5	35.9
Total of *patin* (n=45)		194.9[c]	32.4
Total of earth pond fish (n=45)		127.9[d]	56.4
Total of river net cages fish (n=30)		132.8[d]	64.0
Total of ex-mining pool fish (n=45)		124.3[d]	54.8
Total fish (n=120)		127.7	57.4

Indicator : the same alphabet mean the value had no significant different at $p < 0.05$

serving unit of ready to eat fresh water aquaculture fish that was sold at food premises according to the type of fish and aquaculture system.

Patin has the highest weight (194.9 g) followed by keli (105.4 g) and tilapia (75.5 g) but all the fish had no significant different ($p < 0.05$) of their weight according to the type of aquaculture system as well as the type of food premises. The average weight of one serving unit of ready to eat fresh water aquaculture fish sold at food premises was 127.7 g.

From the questionnaires, it was indicated that the average portion of fish serving unit eaten by consumers per meal was 0.89 for red tilapia, 0.85 (keli) and 0.89 (patin). The number of meals per day that contain fresh water aquaculture fish eaten by consumers was 1.07 for tilapia, 1.07 (keli) and 1.05 (patin) and the average number of days per week where consumers eat fresh water aquaculture fish was 1.2 for tilapia, 1.3 (keli) and 1.1 (patin). After calculation using the specific formula, the average weight of ready to eat fresh water aquaculture fish per meal was 110.1 g, 116.3 g per day and 130.6 g per week. The average weight of fish per meal, per day and per week according to the type of fish and the type of aquaculture system were tabled in Table 7. The values were then used in the calculation of heavy metals risk exposure.

Table 7. The average weight of fresh water aquaculture fish consumed by respondents per meal, per day and per week

Ready to eat fresh water aquaculture fish	Aquaculture system	Average weight of fish consumed per meal (g)	Average weight of fish consumed per day (g)	Average weight of fish consumed per week (g)
Red *tilapia*	Earth pond (n=15)	68.4	73.1	82.0
	River net cages (n=15)	66.8	71.3	81.0
	Ex-mining pool (n=15)	66.4	70.9	80.6
Total red *tilapia* (n=45)		67.2	71.7	81.2
Keli	Earth pond (n=15)	89.3	95.6	113.0
	River net cages (n=15)	89.5	96.2	115.0
Total *keli* (n=30)		89.6	95.9	114.0
Patin	Earth pond (n=15)	179.4	187.5	199.6
	River net cages (n=15)	169.6	177.3	197.1
	Ex-mining pool (n=15)	171.3	179.0	193.1
Total *patin* (n=45)		173.5	181.3	196.6
Total for earth pond fish (n=45)		112.4	118.7	131.5
Total for river net cages fish (n=30)		108.6	114.9	131.0
Total for ex-mining pool fish (n=45)		118.9	125.0	136.9
Total fish (n=120)		110.1	116.3	130.6

Table 8. Average quantity of heavy metal residues in fresh water aquaculture fish and the amount of heavy metals exposure to consumers

Type of fish	Heavy metal residues	Average quantity of heavy metal residues calculated using @Risk 4.5 Excel programme (ppm)	Average amount of fish eaten by consumers recounted using @Risk 4.5 Excel programme (kg)	The amount of heavy metals exposure to consumers (ppm in kg fish weight)
Red *tilapia*	As	0.001235	0.074237	0.000092
	Cd	0.009801		0.000728
	Hg	0.002000		0.000148
	Pb	0.105200		0.007809
Keli	As	0.009818	0.113677	0.001116
	Cd	0.010822		0.001230
	Hg	0.003200		0.000364
	Pb	0.091702		0.010424
Patin	As	0.009500	0.185741	0.001765
	Cd	0.009529		0.001769
	Hg	0.001991		0.000369
	Pb	0.084618		0.015717
Total fish samples	As	0.010072	0.140289	0.001413
	Cd	0.010236		0.001436
	Hg	0.002068		0.000290
	Pb	0.090419		0.012685

Table 9.The value of PTWI of the study, PTWI Standard and % of PTWI of the study compared to PTWI Standard

Type of fish	Heavy metal residues	PTWI of the study	PTWI standard value(Food Regulation 1985)	% PTWI of the study compared to PTWI standard
Red *tilapia*	As	1.40552E-06	0.015	0.01
	Cd	1.11574E-05	0.007	0.16
	Hg	2.27677E-06	0.005	0.05
	Pb	0.000119758	0.025	0.48
keli	As	1.7135E-05	0.015	0.11
	Cd	1.88876E-05	0.007	0.27
	Hg	5.58492E-06	0.005	0.11
	Pb	0.000160046	0.025	0.64
patin	As	2.7327E-05	0.015	0.18
	Cd	2.74103E-05	0.007	0.39
	Hg	5.72837E-06	0.005	0.11
	Pb	0.000243405	0.025	0.97
Total fish samples	As	2.16375E-05	0.015	0.14
	Cd	2.19903E-05	0.007	0.31
	Hg	4.44347E-06	0.005	0.09
	Pb	0.000194243	0.025	0.78

Heavy metals risk exposure

As mentioned in the method of this study, the quantity values of heavy metal residues in the samples were then multiply by the average amount of fish eaten by consumers to get the amount of heavy metals risk exposure to consumers. Other researcher (Asma, 2003) also suggested the same formula while calculating the health risk exposure of the food. Table 8 showed the amount of heavy metals exposure to the consumers which recalculated using computer programme @Risk 4.5 Excel. The use of computer programme @Risk 4.5 Excel allowed more data to be simulated, given smaller standard deviation and the calculation was more precised. The value were then divided by the average respondents' body weight to get the PTWI values and were compared with the standard values of PTWI (Table 9). The level of heavy metal risk exposures to consumers (in term of comparable PTWI unit) to the consumers were found very low i.e 0.14% for As, 0.31% (Cd), 0.09% (Hg) and 0.78% (Pb).

Conclusion

In conclusion, consumers have accepted fresh water aquaculture fish from Malaysia, the fish have very low heavy metals risk exposures and they also have high potential to be developed.

Acknowledgements

The authors would like to convey their gratitude to Department of Health, Pahang, Malaysia for assistant in sampling activity and also to International Islamic University Malaysia for the financial support of this work through research grant: EDW B12-359-0837.

References

Asma, Z. Risk assessment: Principles and components. Presentation Paper at Risk Assessment of Chemical Hazards in Food Seminar, Ministry of Health Malaysia, Genting Highland, 1-4 July 2003.

Ferenc, S. Food safety risk assessment. Presentation paper at Microbiology Risk Assessment Workshop, International Life Sciences Institute South Asia, Manila, 23-24 November 2000.

Food Act 1983 and Food Regulation 1985. Malaysia Act, Act 281. Amendment No.4/2000. Malaysia National Printing Berhad. Kuala Lumpur.

Heever, D.J. and Frey, B.J. 1996. Human health aspects of certain metals in tissue of the African sharptooth catfish, *Clarias gariepinus* kept in treated sewage effluent and the Krugersdrift dam: chromium and mercury. Water-SA 22(1): 73-78.

Iman, M.K.A., Mohammad, M.N., Authman and Wafaa, T. A. 2013. Heavy metal pollution and metallothionein expression: A servey on Egyptian tilapia farms. Journal of Applied Sciences Research 9(1): 612-619.

Internet: Perangkaan Perikanan Tahunan 2007. Department of Fisheries Malaysia. Downloaded from *http://www.dof.gov.my* on 1 April 2013.

Iqbal, H.M., Mustafa, S. and Ahmad, T.S. 2002. Heavy metal concentrations in water and tiger prawn (*Penaeus monodon*) from grow-out farms in Sabah, North Borneo. Food Chemistry 79 (2): 151-156.

Kiat, N. C. 1998. Tilapia culture. In Nagarajah, G. and Singh, T. (Eds). Aquaculture practices in Malaysia, p. 27-33. Serdang: Malaysian Fisheries Society.

Kumar, R. 2005. Fish as a food commodity: Biochemical composition of fish, National Association of Biology Teachers (NABT) Bulletin Board.

Ministry of Agriculture Malaysia, Transformation of agriculture based industry, Presentation paper at Agriculture Based Industry Seminar, Selangor, 12-13 August 2004.

Sara, R. R., Mohd Mansor, I. and Ilmas, A. 2013. Comparative study of brackish water species in Peninsular Malaysian. Annals of Biological Research 4(8): 145-151.

Sidhu, K. S. 2003. Health benefits and potential risks related to consumption of fish or oily fish. Regulatory Toxicology and Pharmacology 38: 336-344.

Simopoulos, A.P. 2004. Omega-6/omega-3 essential fatty acid ratio and chronic diseases. Food Reviews International 20: 77-90.

Smolin, L.A. and Grosvenor, M. B. 2003. Nutrition: Science and applications, 4th Edition, USA: John Wiley and Sons Inc.

Tarek, E. 2011. Evaluation of some heavy metals in *Pangasius hypothalamus* and *Tilapia nilotica* and the role of acetic acid in lowering their levels. International Journal of Fisheries and Aquaculture 3(8): 151-157.