

# **UNIVERSITI PUTRA MALAYSIA**

PCBs AND HEAVY METALS IN FISH AND SHELLFISH, DIETARY EXPOSURE AND NEUROBEHAVIORAL PERFORMANCE AMONG MALAYSIAN FISHERMEN

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FPSK(M) 2011 64

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# UPM

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MASTER OF SCIENCE UNIVERSITI PUTRA MALAYSIA

2011

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By

ALINA BINTI MOHAMAD

This Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

December 2011



As I was writing this thesis, I realized that without my parents I would not be here today. So, I dedicate this thesis to them,

Hj. Mohamad bin Draman

Hjh. Ramlah binti Ali

in remembrance of their loves, guidance and sacrifices.

May Allah bless both of you.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

### PCBs AND HEAVY METALS IN FISH AND SHELLFISH, DIETARY EXPOSURE AND NEUROBEHAVIORAL PERFORMANCE AMONG MALAYSIAN FISHERMEN

By

#### ALINA MOHAMAD

#### **DECEMBER 2011**

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Fish is a high-quality source of protein which also contains vitamins and other important nutrients, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Polychlorinated biphenyls (PCBs) and heavy metals have the potential to accumulate in sediments as well as marine organisms, including in fish which can be transferred to human body via food chain. These contaminants are believed to be responsible for a wide variety of negative effects and may cause neurological and neurophysiological signs and symptoms.

The main objectives of this study was to determine the type and amount of contaminants (PCBs and heavy metals) in fish and shellfish, its dietary exposure and neurobehavioral performance among fishermen along Straits of Malacca. The association between level of exposure and neurobehavioral performance were also determined.

PCBs were prepared and analyzed using method defined by US EPA (Method 1613). For determination of heavy metals, the sample was prepared using method from Falco, et al., (2006). For dietary intakes, the fishermen were measured using Food Frequency Questionnaire (FFQ).

The highest amount of PCBs was in cockles with 2.61 pg/g wet weight while Indian mackerel showed a concentration of 1.37 pg/g wet weight for fish species. For mercury, the highest amount was in Long-tailed butterfly ray at  $0.0163 \pm 0.000 \ \mu$ g/g wet sample. It can be concluded that fish and shellfish caught along the Straits of Malacca are safe to consume in terms of PCBs and heavy metals level.

For dietary exposure study, 90 fishermen participated in the study. The mean exposure to PCBs was  $2.77 \pm 0.261$  pg/ kg bw/ day. The highest mean exposure for heavy metals was arsenic at  $4.517 \pm 0.400$  µg/ kg bw/ day. This study found that the PCBs and heavy metals exposures via dietary intake of fish and shellfish were within tolerable daily intake. Results of Neurobehavioral Core Test Batery (NCTB) showed that 97 % of respondents achieved high score (>30) which mean the neurobehavioral performance was not affected. There were no correlations between dietary exposure of contaminants and neurobehavioral performance among fishermen. As a conclusion, dietary exposure to PCBs and the selected heavy metals via fish consumption was not sufficient to cause neurobehavioral changes among fishermen.

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Data obtained from the present study can be used as preliminary information on levels and types of contaminants in fish and shellfish besides the dietary exposure related to intake of the fish and shellfish. Although the level of exposure was low, there is a potential to be higher in the future. Therefore, further investigation is needed for monitoring of these contaminants in food, especially fish and shellfish. Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

#### PCBs DAN LOGAM BERAT DALAM IKAN DAN KERANG-KERANGAN, PENDEDAHAN DIETARI DAN PRESTASI PERILAKU NEURO DI KALANGAN NELAYAN MALAYSIA

Oleh

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#### **DISEMBER 2011**

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Ikan adalah sumber protein berkualiti tinggi yang turut mengandungi vitamin dan nutrien penting seperti asid eikosapentaenoik (EPA) dan dokosaheksaenoik (DHA). *Polychlorinated biphenyl* (PCBs) dan logam berat berpotensi untuk berkumpul dalam sedimen, dan juga organisma marin, termasuk ikan yang mana ianya dipindahkan ke tubuh manusia menerusi rantaian makanan. Bahan pencemar kimia ini juga dipercayai menjadi punca kepada pelbagai kesan negatif dan boleh menyebabkan simptom dan tanda-tanda neurologikal dan neurofizikal.

Objektif utama kajian ini adalah untuk menentukan jenis dan amaun bahan pencemar (PCBs dan logam berat) dalam ikan dan kerang-kerangan, pendedahan dietari dan perubahan perilaku neuro dikalangan nelayan di sepanjang Selat Melaka. Perkaitan di antara tahap pendedahan dan prestasi perilaku neuro juga ditentukan.

Penentuan PCB disedia dan dianalisis menggunakan prosedur US EPA (Method 1613). Untuk penentuan logam berat, sampel disediakan mengikut prosedur Falco, et

al., (2006). Pengambilan diet nelayan diukur dengan menggunakan Borang Soal Selidik Kekerapan Makanan (FFQ).

Berdasarkan hasil kajian, jumlah tertinggi bagi PCBs adalah dalam kerang pada kepekatan 2.61 pg/g berat basah sementara, kembung mengandungi kepekatan yang tertinggi di kalangan spesis ikan iaitu 1.37 pg/g berat basah. Bagi merkuri, pari mengandungi kepekatan tertinggi iaitu  $0.0163 \pm 0.000 \mu g/g$  sampel basah. Maka, boleh disimpulkan bahawa ikan dan kerang-kerangan yang ditangkap di sepanjang Selat Melaka adalah selamat untuk dimakan dari segi kandungan PCBs dan logam berat.

Bagi pendedahan dietari, seramai 90 orang nelayan telah mengambil bahagian dalam kajian. Purata pendedahan PCBs di kalangan responden adalah  $2.77 \pm 0.261$  pg/ kg. Arsenik didapati menunjukkan jumlah pendedahan tertinggi di kalangan logam berat iaitu sebanyak  $4.517 \pm 0.400 \mu$ g/ kg berat badan/hari. Kajian ini mendapati bahawa pendedahan terhadap PCB dan logam berat melalui pengambilan makanan ikan dan kerang-kerangan adalah dalam pengambilan harian yang dibenarkan. Markah yang diperolehi dalam ujian NCTB di kalangan 97 % responden adalah tinggi (>30) dan ini menunjukkan bahawa prestasi perilaku neuro tidak terjejas. Tiada korelasi wujud di antara pendedahan dietari bahan pencemar dan perbezaan perilaku neuro di kalangan nelayan. Sebagai kesimpulan, pendedahan dietari terhadap PCBs dan logam berat terpilih menerusi pengambilan ikan masih belum mencukupi bagi mengakibatkan prestasi perilaku neuro di kalangan responden.

Data yang diperolehi daripada kajian ini boleh digunakan sebagai maklumat awal mengenai tahap dan jenis pencemaran di dalam ikan dan kerang-kerangan disamping pendedahan yang berkaitan dengan pengambilan ikan dan kerang-kerangan. Walaupun tahap pendedahan adalah rendah, tetapi terdapat potensi untuk peningkatan pendedahan pada masa akan datang. Maka, kajian lanjut diperlukan bagi meneruskan pemerhatian terhadap kandungan bahan pencemar ini dalam makanan, terutamanya ikan dan kerang-kerangan.



#### ACKNOWLEDGEMENTS

Bismillahirrahmaanirrahiim.

In the name of Allah, The Most Gracious, The Most Merciful.

I wish to express my deepest appreciation and gratitude to my dear supervisor, Associate Professor Dr. Azrina Binti Azlan who always inspires, encouragement and guides me throughout this study. I also like to extend my thanks to my co-supervisor, Associate Professor Dr. Mohd. Yusoff Bin Adon for the guidance, ideas, advice and motivation for me to finished this research. It was a really great and unforgettable experience to operate the research under their supervision.

My special appreciation goes to the staff of Faculty of Medicine and Health Sciences, Universiti Putra Malaysia (Pn. Aina) and Department of Biochemistry, Faculty Bioscienes, Universiti Putra Malaysia (Associate Professor Dr. Mohd Yunus bin Abd. Shukor, Mohd Zakiuddin, Mohd Izuan Effendi) and staffs of Doping Control Centre, Universiti Sains Malaysia (Professor Aishah A. Latiff, En. Hajjaj, En. Ali) for their assistance, co-operation, technical supports and guidance in various ways in my laboratory works. I would like to further my thanks to Lembaga Kemajuan Ikan Malaysia (LKIM) for their commitment on helping me to get the sample for used in this study and to all my respondent for giving their time and effort for doing the survey to completed this research. I also want to thank Ministry of Science, Technology and Innovation (MOSTI) for giving me the opportunity to study under the sponsorship of National Sciences Fellowship (NSF). I am grateful for their help and wish to thanks them all.

Last but not least, I wish to convey my gratitude to my family members especially my father and mother, and special thanks to all my dear friends for their endless prayers, support and love. I certify that a Thesis Examination Committee has met on <u>15 December 2011</u> to conduct the final examination of Alina binti Mohamad on her Master of Science thesis entitled "PCBs and heavy metals in Fish and Shellfish, Dietary Exposure and Neurobehavioral Performance among Malaysian Fishermen" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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#### DECLARATION

I declare that the thesis is my original work except for the quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



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# LIST OF ABBREVIATION

| μg    | Microgram                                |
|-------|--|
| AHA   | American Heart Association               |
| As    | Arsenic                                  |
| BMI   | Body Mass Index                          |
| Cd    | Cadmium                                  |
| CHD   | Coronary Health Disease                  |
| cm D  | Centimeter                               |
| DHA   | Docosahexaeonic acid                     |
| EFA   | Essential fatty acids                    |
| EPA   | Eicosapentaenoic acid                    |
| FFQ   | Food Frequency Questionnaire             |
| g     | Gram                                     |
| Hg    | Mercury                                  |
| IARC  | International Agency of Research Cancer  |
| IUPAC | International Union of Pure and Chemists |
| kg    | kilogram                                 |
| MANS  | Malaysian Adult Nutrition Survey         |
| MeHq  | Methylmercury                            |
| mg    | Milligram                                |
| NCTB  | Neurobehavioral Core Test Battery        |
| ng    | nanogram                                 |
| °C    | degree Celcius                           |
| Pb    | Plumbum                                  |

(C)

| PCBs    | Polychlorinated biphenyls                  |
|---------|--|
| pg      | Picogram                                   |
| ppm     | Parts per million                          |
| PTWI    | Provisional tolerable weekly intake        |
| PUFAs   | Polyunsaturated fatty acids                |
| SD      | Standard deviation                         |
| WHO-TEQ | World Health Organization-Toxic equivalent |
| WHR     | Waist Hip Ratio                            |

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#### **CHAPTER 1**

#### **INTRODUCTION**

Fish is a good source for protein where the protein content is similar to land animals (Torpy, 2006). Besides, fish is also high in polyunsaturated fatty acids (PUFA), such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which is important to the diet. Other than that, fish also represents a very important source of vitamin D, which is essential for bone mineralization (Verbeke et al., 2004). Studies showed that intake of 35 g or more fish daily or two fatty fish per week would be beneficial to reduce the relative risk of death from coronary heart diseases (Siscovick et al., 1995, Daviglus et al., 1997).

Although fish contains high amount of beneficial compounds, it also may also contains chemical contaminants that adversely affect the human health. Polychlorinated biphenyls (PCBs), methylmercury, dioxin and other environmental pollutants such as arsenic, cadmium and plumbum are significantly present in some species of the marine products (Kris-Etherton et. al., 2002). These compounds are of higher concern recently because of their toxicity, persistence, bioaccumulation and biomagnifications into the food chain (Castro-González and Méndez-Armenta, 2008; Storelli, 2008). Bacio et al. (2007) reported that meat, dairy products and fish contributed to more than 90% of the intake of PCBs for the general population. These compounds accumulate in a human body through many pathways, including

respiration, absorption and ingestion. However, the easiest route into human is via ingestion (Mendil et al., 2010).

Some of the negative health effects related to PCB exposure are liver enlargement, liver lesions, carcinogenesis and even death (Goldstein and Safe, 1989; Nygren et al., 1986; Poland and Knutson, 1982). Besides, the adverse health effects associated with exposure to heavy metals are neurotoxic, carcinogenic, neurological and neurophysiological signs and symptom (Rohlman et al., 2007).

The levels of environmental pollutants in fish and shellfish from Straits of Malacca could be potentially high due to various industrial activities and being one of the busiest routes in the world. Department of Environment also reported that the concentration of heavy metals was higher in the west coast of Peninsular Malaysia compared to other areas of Malaysian waters. In the year 1990 for example, almost all water samples collected from the coastal waters of Malaysia contained high level of lead, copper and cadmium exceeding the standards of 0.05 mg/litre for lead, 0.01 mg/litre for copper and 0.005 mg/litre for cadmium. The coastal waters of Penak and Penang were recorded to contain higher levels of cadmium, copper, lead, mercury and nickel in the water because of extensive land use and industrialization (Choo et al., 1995).

#### **Problem statement**

Up to date, various levels of PCBs concentrations in various species were detected from different countries including Spain (Bocio et al., 2007), Ireland (Tlustos et al., 2006) and Scotland, UK (Jacobs et al., 2002). Yet, in Malaysia, the data on PCBs in food are still lacking. However, there were still some studies on heavy metals from Malaysia, such as Hajeb et al., (2009), Irwandi and Farida (2009) and Kamaruzzaman et al., (2010). However, in these studies, they only determined for mercury, plumbum, and cadmium. Although data on selected heavy metals are available, the species and location were different. Bocio et al. (2007) reported that in sardine species, the amount of PCBs was at 1.41 pg WHO-TEQ/g wet weights from Catalan market, while Hejap et al. (2009) found the highest amount of mercury in short-bodied mackerel with  $0.15 \pm 0.38 \,\mu g/g$  wet weights collected from local Malaysian market. The levels of both contaminants were clearly high, so it is possible that the species from Straits of Malacca could have high level of contaminants too as the Straits of Malacca is the busiest route in the world. Therefore, this study is important to gather relevant information on levels of PCBs and heavy metals from the Straits of Malacca.

In the year 2000, statistics have shown that the per capita food supply from fish and fishery products was 58 kg per person in Malaysia (World Resources Institute, 2003). Besides, the Malaysian Adult Nutrition Survey (MANS) in year 2008, also reported high prevalence of daily consumption of marine fish among rural and urban adults at 51% and 34%, respectively (Norimah et al., 2008). In other words, marine fish are the major source of protein (60-70%) in Malaysian population (Malaysian

Agriculture Directory & Index (1993/1994). A review by Domingo and Bocio (2007) showed that populations in 4 major continents who frequently consume high quantities of certain fish species had significantly increased health risks due to PCBs and dioxin/furan intake. Previously, study done among fishermen in Baltic Sea, Sweden has shown that fishermen were more exposed to PCBs and heavy metals due to their high intake of fish and shellfish (Svensson et al., 1995). Hence, the objective of this study was also to determine the exposure of contaminants through dietary intake and the relationship between the neurobehavioral performances among fishermen community.

#### Significance of the study

Finding of this study would generate preliminary data on levels and types of contaminants in fish and shellfish beside the dietary exposure related to intake of the fish and shellfish. This study would also identify the correlation and related neurobehavioral performances occurred. On the other hand, it also gives information on the safety aspect of local fish and shellfish, which is becoming more important as consumers nowadays are aware on the advantageous of fish intake.

#### **Objectives**

#### **General Objective:**

To determine the type and amount of contaminants (PCBs and heavy metals) in fish and shellfish, its dietary exposure and neurobehavioral changes among fishermen along Straits of Malacca

#### **Specific Objectives:**

- 1. To identify the type and amount of polychlorinated biphenyls and its congeners in marine fish and shellfish samples
- 2. To determine the concentrations of heavy metals; mercury, arsenic, cadmium, plumbum in marine fish and shellfish samples
- 3. To determine the exposures to PCBs and selected heavy metals via dietary intake of fish and shellfish among fishermen
- 4. To determine the neurobehavioral performance and association between level of exposure and neurobehavioral performance among the fishermen



Figure 1: Conceptual framework of the study

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