Evaluation of trace elements iron, zinc, copper and lead In the diet of female university students

Zawiah Hashim & Rosmiza Abd. Hamid

Department of Nutrition & Dietetics, Faculty of Allied Health Sciences, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur.

ABSTRACT

Food consumption of 50 female students in Universiti Kebangsaan Malaysia was recorded for 7 days. Foods and drinks most frequently consumed were selected for analysis of iron, zinc, copper and lead content. The mean daily intakes of energy, protein, carbohydrate and fat among the students are 6.5±1.4 MJ (1550±335 kcal), 59.8±18.5g. 227. 1±54.6 g and 46.0±11.5 g respectively. This diet contributed 19.6±6.4 mg Fe, 7.0±2.0 mg Zn and 1.6±0.6 mg Cu per day which were lower than the Malaysian RDA for Fe and US RDA for Zn, while Cu is within the recommended range. The main sources of these minerals in the student's diet were rice, rice products, meat and animal products. Lead concentration in the diet (134±77 ug / day) is below the acceptable daily intake (ADI) value suggested by Codex Alimentarius Commission (1984). This study indicated concern regarding the low intake of the essential trace elements on long term basis among the students.

INTRODUCTION

There has been a remarkable expansion in the knowledge of the significance of trace element and the effect of its absence on human health. Recent studies examining the need for various trace and ultratrace elements by animals under some form of nutritional, metabolic, hormonal or physiologic stress have indicated that these are situations in which some of the trace elements maybe of nutritional significance (Nielsen, 1989). Dietary trace element deficiency can alter the Intermediary metabolism of cells and their energy production. Total diet studies to monitor the exposure to additives and contaminants through habitual diet in the Netherlands revealed that toxic heavy metals in Dutch total-diet samples of male adolescents are of little concern as regards health aspects, while Fe and Cu contents seem to be marginal (van Dokkum *et al.*, 1989). Reilly (1985) reported that the metal content of food was generally related to metal in immediate contact with food that is the cooking utensils and the domestic water supply. In

Malaysia, several dietary intake studies of adults have been carried out listing various techniques and intake of iron have been widely reported (Fatimah, 1988; Zawiah, Norimah & Fauziaih, 1990; Norimah & Abu Bakar, 1993; Winnie, 1994). Zawiah & Rosma (1991) and Chan (1993) has reported studies on zinc status in pregnant women and adolescent respectively. No matter how biologically and nutritionally important Zn is diagnosis of Zn deficiency is hampered by the lack of a single, specific and sensitive biochemical Index of Zn status (King, 1990). A few studies on the content of these trace elements including Pb in various species of fish from local sources have been reported (Dayang Aminah *et al.*, 1994; Ahmad, Ahmad Badri & Ahmad Abas, 1994). These studies reported contents of Cd, Pb, Zn and Cu In fishes were lower than the maximum limit allowed by the Food Act 1985.

The present study deals with the assessment of some essential trace element intake from diets selected by female students on campus at University Kebangsaan Malaysia and the exposure to a heavy metal lead (Pb) by comparing contents in diet with the acceptable daily intake (ADI) established by FAO/WHO (Codex Alimentarius Commussion, 1984).

SUBJECTS AND METHODS

Subjects

This study involved 50 Malay female students aged between 20 -24 years staying in one dormitory where there were no cooking facilities. Hence all these students took most of their meals in the cafetaria at the dorm. Sometimes they ate in a few other cafeterias on campus.

Methods

The students were given a briefing on the objectives of the study. They were requested to keep a one week dietary intake record that is recording all foods and drinks consumed for that duration. Sincerity and accuracy of keeping records was stressed. The subjects were asked to estimate the foods they eat based on household measures, serving size and cost of the food. The weight of food estimated was validated by purchasing the foods from the same place the subjects bought their foods and actually weighing them.

From the dietary record, intake of major nutrients such as energy, protein, carbohydrate and fat were calculated based on Nutrient Composition of Malaysian Foods (Tee *et al.*, 1988). Frequency of intake were listed and samples were purchased for trace element analysis based on foods consumed more than three times per week. Table 1 lists the 25 food samples selected for analysis. The food samples were not duplicate diets consumed by the students. However these foods were served at the cafetaria daily by the same contractor. These were foods available to the student groups for as long as they are staying at the dormitory. Moreover, the one week food intake record provide accurate enough information on the types of foods selected and consumed daily.

Table 1. Food samples selected for analysis

1.	Cooked white rice.
2.	'Nasi lemak' - rice cooked with coconut milk and eaten with anchovies fried with chili paste.
3.	Fried rice.
4.	Fried mee - noodle made from flour.
5.	Fried mee hoon - noodle made from rice flour.
6.	Red fish curry (red snapper)
7.	Fried fish (Indian Mackerel)
8.	Indian mackerel fried in soy. sauce.
9.	'Cencaru' in chili sauce (Hairtail scad)
10.	Fried chicken.
11.	Chicken fried in soy sauce.
12.	Chicken fried in chili sauce.
13.	Chicken soup.
14.	Beef cooked in chili sauce.
15.	Squid fried in chili sauce.
16.	Cockles fried in chill sauce.
17.	Chicken liver cooked with curry paste.
18.	Fried spinach.
19.	Fried water hyacinth (kangkong)
20.	Fried cabbage
21.	Fried 'tempeh' (fermented soy bean)
22.	Bread
23.	Crackers
24.	Milo
25.	Tea

A few food samples were purchased at a time based on what was available in the cafetaria. Each food samples were bought on three separate occasions. Precautious were taken to avoid environmental contamination. A duplicate 5 g homogenized samples of each food were dried at 100 0 C to constant weight. The dried samples were then ashed in porcelain crucibles at 525 0 C in a muffle furnace for 24 hours or until a white ash was obtained. The ash was dissolved in concentrated HCI and analysed using atomic absorption spectrophotometer Pye Unicam Model 5P9 (AOAC, 1984). Standard curves were prepared with the following detection limits, Fe, 0.0 -25.0 ug/ml, Zn and Cu, 0.0 - 10.0 ug/ml and Pb, 0.0 - 4.0 ug/ml. The results were used to calculate trace element intake from daily diets selected by the students instead of using results from the nutrient composition of Malaysian foods which do not contain values for Zn, Pb and Cu.

Statistical analysis

Results are presented as mean ± SD and range. Contribution of trace element from different sources

are given as percentage of total daily intake.

RESULTS

The mean daily intake of major nutrients and percentage contribution of protein, fat and carbohydrate to energy intake are shown In Table 2. Energy intake among the students ranges from 3.6 -9.1 MJ (860 - 2180 kcal) with a mean of 6.5 MJ (1550 kcal). Percentage of students with intake lower than RDA for energy is 90% and protein is 2%. Contribution of protein, fat and carbohydrate to energy is 15, 27 and 58% respectively.

Intake of Fe, Zn and Cu from the daily diet are presented in Table 3. Mean intake of Fe and Zn are lower than RDA while intake of Cu falls within the recommended range. Rice, rice dishes, noodles, fish and meat are the main source of these trace elements (Table 4). About 28%, 31% and 31% of daily intake of Fe, Zn and Cu respectively comes from rice and noodles, meat and seafoods provide 19% and 17% respectively for Fe, 26% and 13% for Zn and 21% and 16% for Cu.

Table 5 lists the content of trace elements Fe, Zn and Cu in the foods analysed. Chicken liver dish showed the highest content of Fe and Zn.

Table 2. Mean daily intake of major nutrients among the students

Nutrient	*Mean ± SD (n=50)*	*Range*	*Percentage < RDA**	*Percent Contribution to calorie (%)*
Energy (MJ) (kcal)	6.5 ± 1.4 (1550 ± 335)	3.6 – 9.1 (860 – 2180)	90	–
Protein (g)	59.8 ± 18.5	30.9 – 87.5	2	15
Fat (g)	46.0 ± 11.5	21.0 – 64.5	–	27
Carbohydrate (g)	227.1 ± 54.6	102.4 – 339.0	–	58

*RDA for females age 20 – 39 years
Energy – 8.3 MJ (2000 kcal)
Protein – 37 g

Table 3. Intake of iron, zinc and copper from diet

Nutrient	*Mean ±SD*	*Range*	*RDA*
Iron (mg/day)	19.6 ±6.4	11.7 – 30.5	28[a]
Zinc (mg/day)	7.0 ±2.0	3.8 – 11.5	12[b]
Copper (mg/day)	1.6 ±0.6	0.4 – 3.2	1.5 – 3.0[b]

[a] RDA Malaysia (Teoh, 1975)
[b] RDA U.S.A. (National Research Council, 1989)

Table 4. Main sources of iron, zinc and copper in the students diet

Food	*Amount per person per day and percent of daily intake*					
	Fe		*Zn*		*Cu*	
	mg/day	*% intake*	*mg/day*	*%intake*	*mg/day*	*% intake*
Rice, rice dishes, noodles	5.5	28.1	2.2	31.4	0.49	30.6
Fish, sea-foods	3.4	17.3	0.9	12.9	0.26	16.2
Meat	3.8	19.4	1.8	25.7	0.34	21.2
Vegetables	2.6	13.3	0.4	5.7	0.18	11.3
Drinks	2.5	12.7	1.2	17.1	0.22	13.8
Others	1.8	9.2	0.5	7.2	0.11	6.9
	19.6	100	7.0	100	1.60	100

Table 5. Trace element contents in cooked foods

Dish	*Mean* (mg/100g)*		
	Fe	*Zn*	*Cu*
Rice	1.27	0.41	0.06
'Nasi lemak'	1.25	0.68	0.10
Fried rice	0.97	0.44	0.08
Fried mee	1.00	0.07	0.16
Fried mee hoon	2.50	0.22	0.10
Red snapper curry	3.87	1.08	0.50
Fried fish (Indian mackerel)	2.83	1.17	0.48
Indian mackerel (in soy sauce)	3.07	0.80	0.39
Hairtail scad (with chili sauce)	3.03	0.97	0.29
Fried chicken	3.63	1.29	0.25
Chicken fried in soy sauce	3.60	1.25	0.39
Chicken fried with chili	3.33	1.16	0.22
Chicken soup	3.67	1.07	0.37
Beef cooked with chili sauce	4.37	1.87	0.47
Squid fried with chili sauce	2.80	1.53	0.39
Cockles fried with chili sauce	1.93	1.67	0.38
Chicken liver	7.57	2.67	0.33
Fried spinach	4.80	0.83	0.12
Fried water hyacinth	3.27	0.17	0.09
Fried cabbage	1.40	0.20	0.08
Fried 'tempeh'	2.20	0.71	0.18
Bread	2.60	0.45	0.08
Crackers	1.60	0.54	0.10
Milo	0.85	0.80	0.20
Tea	0.80	0.19	0.16

*Mean of three samples purchased on different days

Lead intake from the student's diet ranges from 0 - 333 ug / day with a mean of 134 ± 77 ug / day (Table 6a). The mean daily intake of Pb in various countries is shown in Table 6b. The Pb content in the students diet is shown in Table 7. The highest content of Pb were found in fish and seafood (57.3 ug / day) followed by drinks (45.2 ug / day) and vegetables (21.6 ug / day). When the amount of Pb consumed is compared to the ADI (Table 6a) it showed that this element is below the ADI value.

Table 6a. Intake of lead (Pb) by students from daily diet

Mineral	Mean±SD	Range	ADI*
Pb (ug / day)	134±77	0-333	430

*ADI – FAO / WHO (Codex Alimentarius Commission, 1984)

Table 6b. Mean daily intake of lead in various countries

Country	*Intake (µg)*	*References*	*Method & Subject*
Present study (Malaysia)	134		Diet analysis for female adults
The Netherlands	32	Van Dokkum (1989)	'Market basket' for male adolescents
United Kingdom	115	Hazell (1985)	Adults
USA	82	Gartrell *et. al.* (1985)	'Market basket' for 16–19 year old males
Belgium	179	Buchet *et. al.* (1983)	Duplicate diets, adults
Canada	54	Dabeka *et. al.* (1987)	Duplicate diets, adults.

Table 7. Dietary sources of lead in students diet

Food	*µg/day*	*Percent of daily intake*
Fish, seafood	57.3	42.8
Drinks	45.2	33.7
Meat	5.8	4.3
Vegetables	21.6	16.1
Others	4.1	3.1
Total	134.0	100

DISCUSSION

The mean daily energy intake of the 50 female students studied was lower than RDA. The values range from 3.6 - 9.1 MJ (860 - 2180 kcal) with 90% of the subjects taking energy below RDA (Table 2). Other studies in Malaysia have reported similar findings (Zawiah *et al.*, 1990: Ismail, Wong & Zawiah, 1988; Ismail & Zawiah, 1989). The mean energy intake of 6.5 ± 1.4 MJ (1550 ± 335 kcal) in this study is similar to a study on female students by Ismail & Zawiah (1989) with intake of 6.6 ± 1.3 MJ (1590 ±323 kcal) per day. The ratio of 15%: 27%: 58% contribution to energy from protein, fat and carbohydrate respectively is in accordance with the healthy diet guidelines.

Several studies have shown protein intake to be adequate or higher than recommended. In the present study only two percent of the subjects showed protein Intake lower than RDA. This study did not differentiate contribution of protein intake from animal and plant sources.

Intake of Fe and Zn were lower than the RDA for both trace elements (Table 3). Fe intake showed a wide range of 11.7- 30.5 mg/day with a mean of 19.6 mg/day. Previous study on Malay female students reported a lower average intake of 15.5 ± 2.5 mg/day (Zawiah *et al.*, 1990) While Winnie (1994) reported average

Intake of 12.2 mg among 91 Malay female adults. Other studies have reported values between 13.7 mg -18.7 mg / day in pregnant women and diabetic patients (Fatimah, 1988; Zawiah *et al*, 1990, Norimah & Abu Bakar, 1993). Those with low intake were those with energy intake of less than 5 MJ (1200 kcal) per day. Similar finding was obtained for Zn. Meanwhile, mean intake for Cu is within the range provided for RDA. From the results obtained the amount of Fe and Zn from the diet is not acceptable from the nutritional point of view. A study on trace elements in total diets in The Netherlands reported Fe and Cu to be on the low side of the recommendation (van Dokkum *et al*, 1989). In the case of Fe, the amount consumed can be considered adequate when compared to the USA recommended intake (National Academy of Sciences, 1989) but low based on Malaysian RDA. The highest percentage of Fe intake were provided by rice and noodles dishes followed by fish and meat dishes despite having higher content of Fe (Table 5). This is due to the larger amounts of rice and noodles being consumed as compared to the meat or fish dishes. For instance up to 300 g of rice was consumed per day. It was reported that the main source of Fe in the UK diet was cereal and meat which provide 4.4 mg / person / day or 39% of the daily Intake and 2.7 mg / person / day respectively (Ministry of Agriculture, Fisheries and Food, 1980). The finding was true for both Zn and Cu.

With reference to the present study with a mean protein intake of 59.8 g, it can be seen that Zn status in the students maybe low using protein evidence of 1 mg Zn for 10 g protein in diet, assuming 1/2 - 2/3 protein comes from animal source (Personal Communication). This seems true since the mean intake of Zn in the present study is 7.0 mg with a range of 3.8 - 11.5 mg. A study by Sloane, Gibbons & Hagsted (1985) reported mean daily intake of Zn among white and black adolescent females to be 9.3 ± 4.5 and 9.6 ±3.3 mg / day respectively, which was higher than the present study. This may be because Americans consume greater amount of meat which is a richer source of Zn. Zinc and iron compete with copper for absorption (Underwood, 1977) which is believed to be related to competition for binding sites on metallothionein in the intestinal mucosal cells (Fisher, Giroux & L'Abbe, 1981).

Only one toxic metal was analysed in the present study. Total daily exposure to lead from diet was well below the ADI (Table 6a). Similar results were reported in other studies, however samples analysed were collected by different methods and values concern diets of different age groups (Table 6b). In the present study, the higher value in the range of exposure to Pb should be noted. The major source of Pb in the students diet seemed to be from fish and seafood dishes followed by drinks mainly tea and milo. Pb levels in a few species of fishes from local waters were below the maximum limit for safety (Dayang Aminah *et al.*, 1994, Ahmad *et al.*, 1994), hence not posing danger to consumers when contaminated during the cooking process. The nutritional and toxicological significance of this can be considerable since continuous

consumption from the same source could lead to an intake exceeding the recommended safe level.

CONCLUSION

In conclusion, the energy intake among female students are lower than recommended but should not be a source of concern since they are a sedentary group. Protein in the diets however exceed the recommendation and the percentage contribution of energy from protein, fat and carborhydrate is desirable. However intake of essential trace elements such as Fe and Zn from the selected diets should be of concern if similar diet selection is to be practiced over a long period. One recommendation is to educate the students to enable them to make a wiser selection of foods available in the cafetaria. Similar studies should be carried out on various age groups and to cover other essential trace elements as well as contaminants either from cooking utensil or water supply.

ACKNOWLEDGEMENT

The authors thank Universiti Kebangsaan Malaysia for enabling this project to be carried out, Encik Ahmad Shukri Aziz for assistance in the trace element analysis and Puan Nor Hayati Jahid for typing this manuscript. To all the students Involved we appreciate their participation.

REFERENCES

Ahmad I, Ahmad Badri M & Ahmad Abas K (1994). Kandungan logam berat Pb, Zn, Cu, Cd, Fe and Mn dalam Ikan di Tasik Chini. In *Kesatuan Dalam Kepelbagaian Penyelidikan Biologi,* eds Rohani Ahmad *et al.,* pp 328-334, Universiti Kebangsaan Malaysia.

AOAC (1984). *Official Methods of Analysis,* 14th edn, Association of Official Analytical Chemists, Washington, D.C.

Buchet JP, Lauwerys R, Vandevoorde A & Pycke JM (1983). Oral daily intake of cadmium, lead, manganese, copper, chromium, mercury, calcium, zinc and arsenic in Belgium: a duplicate meal study. *Food and Chem Toxicol* 21: 19-24.

Chan S (1993). *A Study on zinc status among adolescents at Maktab Yayasan Pelajaran MARA, Bangi.* B.Sc Thesis, Universiti Kebangsaan Malaysia.

Codex Alimentarius Commission (1984). Contaminants: Joint FAO/WHO food standards program. *Codex Alimentarius* Vo1XVIIEd 1.

Dabeka RW, Mc Kenzle AD & Lacroix GMA (1987). Dietary intakes of lead, cadmium, arsenic and fluoride by Canadian adults: a 24 hour duplicate diet study. *Food Addit Contain* 4(1):89-102.

Dayang Aminah A, Lee N, Choo WY, Badri MA & Abdul Salam B (1994). Kepekatan logam berat pada lima spesies ikan di Sabah. In *Kesatuan Dalam Kepelbagaian Penyelidikan Biologi,* Rohani Ahmad *et al.*(eds). Universiti Kebangsaan Malaysia, pp 3 19-327.

Fatimah A (1988). The etiology of iron deficiency anemia during pregnancy among rural women in Malaysia. *Proc Nutr Soc Mal* 7-15.

Fisher PWG, Giroux A & L' Abbe MR (1981). The effect of dietary zinc on intestinal copper absorption. *Am J Clin Nutr* 34:1670-1675.

Gartrell MJ, Craun JC, Podrebarac DS & Gunderson EL (1985). Pesticides, selected elements and other chemicals in adult total diet samples, October 1978 - September 1979. *J of Assoc Off Anal Chem* 68:862-875.

Zawiah H, Nasir H, Sham K & Aminah A (1990). Dietary intake during pregnancy and birth weight: Public versus Private Institutions *Malays Appl Blot* 19(1): 1-11.

Hazell T (1985). MInerals in foods: dietary sources, chemical forms, interactions, bioavailability. *Wld Rev Nutr Dietet* 46:1-123.

Ismall MN, Wong TS, Zawiah H (1988). Anthropometric and food intake studies among semai children. *J Mal Soc Health* 6(1): 19-25.

King JC (1990). Assessment of zinc status. *J Nutr* 120:1474-1479.

Ismail MN, Zawiah H (1989). Kajian keperluan dan keseimbangan tenaga di kalangan pelajar dan pekerja universiti. *Penyelidikan Semasa Sains Hayat*, pp 107-123.

Ministry of Agriculture, Fisheries and Food (1980). Household Food Consumption and Expenditure, HMSO, London.

National Research Council (1989). *Recommended Dietary Allowances.* 10th Edition. National Academy Press, Washington, DC.

Nielson FH (1989). Recent advances in human trace and ultratrace element nutrition. In *Proceedings of the 14th International Congress of Nutritional*, Young KW *et al* (eds). Seoul, Korea, pp 184- 187.

Norimah AK & Abu Bakar AAH (1993). Food intake and authropometric status of diabetics attending Universiti Kebangsaan Malaysia (UKM) outpatient clinic. *Proc Nutr Soc Mal* 8:16-22.

Reilly C (1985). The dietary significance of adventitious iron, zinc, copper and lead in domestically prepared food. *Food Additives and Contaminants* 2(3): 209-2 15.

Sloane BA, Gibbons CC & Hagsted M (1985). Evaluation of zinc and copper nutritional status and effects upon growth of Southern adolescent females. *Am J Clin Nutr* 42:235-241.

Tee ES, Mohd Ismail N, Mohd Nasir A & Khatijah I (1988). *Nutrient Composition of Malaysian Foods.* ASEAN Food Habits Project, National SubCommittee on Protein: Food 40 *Zawiah H & Rosmiza AH* Habits Research and Development Malaysia.

Teoh ST (1975). Recommended daily dietary intake for Peninsular Malaysia. *Med J Mal* 30:38-42.

Underwood EJ (1977). *Trace elements in human and animal nutrition.* Academic Press, London.

Van Dokkum W, De Vos RH, Muys TH & Wesstra JA (1989). Mineral and trace elements in total diets in The Netherlands. *Brit J Nutr* 61:7- 15.

Chee WSS (1994). *Kajian penilaian anthropometri dan pengambilan makanan di kalangan populasi dewasa di empat kawasan terpilih di Malaysia.* M.Sc Thesis, Universiti Kebangsaan Malaysia.

Zawiah H, Nasir H, Sham K & Aminah A. (1990). Dietary intake during pregnancy and birth weights: Public versus Private Institutions. *Malays Appl Biol* 19(1):1-11.

Zawiah H, Norimah AK & Fauziah A (1990). Evaluation of iron status among Universiti Kebangsaan Malaysia Students. *J MaI Soc of Health* 8(1):39-42.

Zawiah H & Rosma I (1991). Third trimester serum zinc concentration in normal pregnancy. *J Perubatan UKM* 13(1): 45-52.