Elemental Concentrations and Risk Assessment of Heavy and Toxic Metals in Some Instant Foods

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Abstract

Energy Dispersive X-rays Fluorescence (EDXRF) technique was used to analyze the elemental concentrations of some heavy and toxic metals in some instant food samples. For all measured samples, the mean concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn, and As are within their respective safe limit except Cd and Hg. It was found that the mercury concentration in instant noodles samples is significantly the highest among the instant food samples. No risk was found for the elements of Cr, Mn, Fe, Co, Ni, Cu, Zn, and As. But, the elements, Cd and Hg, were found to cause the risk to the consumers by consuming the instant foods.

Key words: EDXRF, Heavy and Toxic Metals

1. Introduction

Instant foods are widely used in both urban and rural areas in Myanmar. The most widely used instant foods are instant noodles, instant coffee-mix and instant tea-mix. Most of the people in both urban and rural area widely use these instant foods. Especially, instant coffee-mix and instant tea-mix are in daily intake in drinking.

Instant foods are inexpensive and widespread expressed as economic indices. Apart from their relatively low price, they have a desirable texture that matches consumer preference and they are easy to produce. These attributes are partly due to the frying process used in their manufacture. Frying not only creates a higher rehydration rate, but it also delivers a delicious taste to the final product of the instant foods.

Instant foods are a kind of food in Myanmar. In instant or ready-made food, there is a little bad side effect because of heavy metals. Heavy metals are highly persistent and non-biodegradable contaminants that cause toxic effect in humans and may be bio-accumulated through food chain to hazardous level, thus posing potential health risks to human by consumption. Toxic elements are naturally present at very low concentrations in environment, and human bodies are able to detoxify them in limited amount. The actual process for instant foods manufacture may differ from company to company and from country to country, but the basic principles involved in the manufacture are practically the same. But certain factors could be considered in evaluating instant food quality such as flour quality, processing conditions, eating quality and keeping quality.

Heavy metals are not easily biodegradable and it leads to their accumulation in human vital organs causing varying degree of illness on acute and chronic exposure. Heavy metals are classified into two main categories i.e. essential and toxic heavy metals. Essential heavy metals (Cu, Co, Zn, Fe, Ca, Mg, Se, Ni and Mn) are required in trace quantities for the proper functioning of enzyme systems, hemoglobin formation vitamin synthesis in human but metabolic disturbances are encountered in excess of these essential metals. Toxic heavy metals (Pb, Cd, As, Hg and Cr) are from the prevalent toxic elements in food and environment that have a long half-life after the absorption in humans and animals can make unsought and unpleasant effects such as damage to internal organs, the nervous system, kidneys, liver and lungs. Ready-made foods are not suitable for long-term use for health due to the effect of toxic elements in these instant foods.

The objectives of this research are (1) to quantify the elemental concentrations in some instant food samples, (2) to investigate the average daily intake of toxic elements associated

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with index in these samples, and (3) to evaluate the integrated health risk assessment for heavy metals through various exposure pathways for consumers.

2. Materials and Method

2.1 Materials

Three kinds of instant food and drink were examined in this study; these are instant coffee-mix, instant tea-mix and instant noodles. The seven instant coffee-mix samples, six instant tea-mix samples, and five instant noodle samples were collected from the local markets. A packet of the instant coffee-mix and instant tea-mix has a net weight of 20 gram. The amount of net weight contained in a packet of instant noodle is 50 gram.

2.2 Method

In order to measure the elemental concentration of the sample, energy dispersive X-ray fluorescence (EDXRF) method was used in this study. The X-ray measurement has been performed in Experimental Nuclear Lab, Department of Physics, University of Mandalay.

3. Data Analysis

3.1 Metal Pollution Index (MPI)

Metal Pollution index (MPI) is one of the indexes associated with food and foodstuff, which is to determine the overall trace elements concentrations in different foodstuff analyzed. This index is obtained by calculating the mean concentrations of all metals in different foodstuff as follows.

$$\text{Metal Pollution Index (MPI) } (\mu g/g) = (Cf_1 \times Cf_2 \times \ldots\ldots \times Cf_n)^{1/n} \qquad (1.1)$$

where, Cf_n = Concentration of metal in "n" in the sample.

3.2 Daily Intake of Metal (DIM)

The daily intake of metals (DIM) was determined by the following equation:

$$\text{Daily Intake of Metals (DIM)} = \frac{C_{metal} \times C_{factor} \times C_{food\ intake}}{B_{average\ weight}} \qquad (1.2)$$

where, C_{metal} is the heavy metal concentration in foodstuff , C_{factor} is conversion factor, $D_{food\ intake}$ is daily intake of foodstuff, and $B_{average\ weight}$ is average body weight.

For the conversion of fresh to dry weight, the factor of 0.84 was used for instant food samples. For a person, the average daily instant food intakes vary according to locality and their life style. The average body weight ($B_{average\ weight}$) was taken as 55 kg for Myanmar.

3.3 Health Risk Index (HRI)

Health risk index (HRI) is the ratio of daily intake of metal (DIM) to the reference dose (RD), and it is defined as the maximum tolerable daily intake of a specific metal that does not result in any harmful health effects. If the value of HRI less than one, the exposed population is said to be safe and if greater than one indicates that there is a potential risk associated with that metal. The health risk index (HRI) was calculated by using the following equation, and the oral reference dose for some elements is shown in Table 1.

$$\text{Health Risk Index (HRI)} = \frac{\text{Daily Intake of Metal (DIM)}}{\text{Reference Dose (RD)}} \qquad (1.3)$$

3.4 Integrated Health Risk

In order to evaluate the potential risk to human health through more than one heavy metal, the integrated health risk (IHRI) or hazard index (HI) has been developed (USEPA, 1989). The hazard index is the sum of the hazard quotients as described in the following

equation. It is assumed that the magnitude of adverse effect will be proportional to the sum of multiple metal exposures.

$$HI = \sum HQ = HQ_{Cr} + HQ_{Zn} + HQ_{As} + HQ_{Cd} + HQ_{Hg} \quad (1.4)$$

The data were statistically calculated by using Microsoft Excel 2007. The measured data were expressed in terms of means and standard deviation.

4. Results and Discussion

4.1 Results

The elemental concentrations of some elements in three different instant food samples are shown in Table 2, and the metal pollution index for these samples are shown in Table 3. Table 4 shows the health risk index for these instant food samples. The relationship between the integrated health risk (IHRI) and the consumption rate for instant foods are shown in Figure 1.

4.2 Discussion

The concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn and As are under their respective safe limit. The concentration of Cd in the instant coffee-mix is over safe limit and that in the instant tea-mix is near safe limit. The Hg concentrations for all samples are over the safe limit in which, Hg concentrations in the instant coffee-mix and tea-mix are more than 30 times of the safe limit whereas that of the instant noodles is more than 40 times of the safe limit.

The instant noodle samples have the highest MPI value among the samples with low range of variation. When the hazard index exceeds one, there is a concern for potential health effects. Even though there was no apparent risk when each metal was analyzed individually, the potential risk could be multiplied when considering all heavy metals. The Hg risk has been observed in all samples, by the consumption of the instant food for one packet per day. Only the Hg risk has been observed by consuming one packet per day of the instant coffee-mix and instant tea-mix. Not only the Hg risk but also the Cr, As and Cd risks have been observed in consuming one packet per day of the instant noodles.

Table (1) Oral reference dose for some elements

Elements	Oral Reference Dose (μg/kg/day)	Reference
Cr	5	FAO/WHO (2013)
Mn	5000	Feriberg et al. 1984
Fe	60000	Feriberg et al. 1984
Co	3010	Food and Nutrition Board (2004)
Ni	20	IRIS-USEPA (1995)
Cu	40	USEPA (1989)
Zn	300	USEPA (1989) FAO/WHO (2013)
As	0.3	IRIS-USEPA (1995)
Cd	1	IRIS-USEPA (1995)
Hg	0.3	IRIS-USEPA (1995)

Table (2) Elemental concentrations of the instant foods samples

Elements	Instant Coffee-mix			Instant Tea-mix			Instant Noodles			Safe limit (mg/kg)
	Mean (mg/kg)	S.D	CV(%)	Mean (mg/kg)	S.D	CV(%)	Mean (mg/kg)	S.D	CV(%)	
Cr	6.26	0.58	9.31	6.43	0.58	9.05	9.02	0.74	8.2	50†
Mn	10.31	0.86	8.35	48.42	9.64	19.92	39.12	7.17	18.33	500*
Fe	1.07	0.19	17.64	6.27	8.26	131.75	170.8	72.2	42.27	425*
Co	3	0	0	3	0	0	3	0	0	50*
Ni	0.4	0.1	25	0.4	0.09	22.36	0.42	0.04	10.65	4‡
Cu	1.37	0.18	13.12	1.5	0.15	10.33	2.74	0.18	6.63	73*
Zn	2.63	0.35	13.31	3.92	0.59	15.01	7.56	0.47	6.24	100*
As	0.37	0.05	13.14	0.35	0.05	15.65	0.5	0.07	14.14	7†
Cd	1.76	0.64	36.57	1.08	1	92.75	1.4	0.82	58.9	1.5**
Hg	1.19	0.07	5.82	1.13	0.14	12.06	1.4	0.1	7.14	0.03*

*FAO/WHO food standard program 2001, †WHO(1996), ‡Food and Nutrition Board, Institute of Medicine (2010), **Indian standard (Codex & Alimentarius,2001)

Table (3) Metal pollution index in mg/kg for the instant foods

Samples	No. of samples	Mean	S.D	CV(%)
Instant Coffee-mix	7	9.21	1.74	18.89
Instant Tea-mix	6	9.11	1.54	16.88
Instant Noodles	5	11.07	1.01	9.15

Table (4) The health risk index for the instant foods

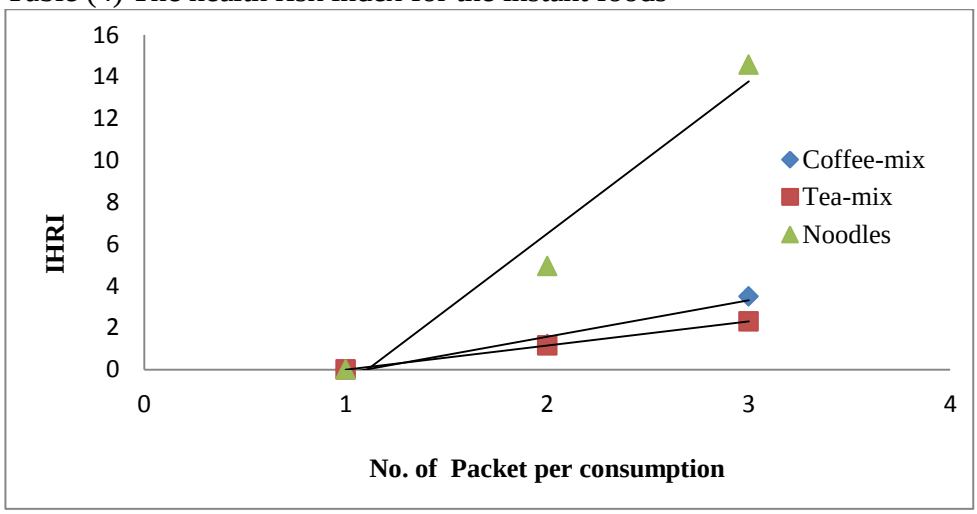

Figure (1) IHRI versus consumption rate curve

The IHRI for the instant noodles (one packet per day) is higher than that for the instant coffee-mix and the instant tea-mix (one packet per day). The IHRI value and the consumptions rate for the instant foods are linearly proportional.

5. Conclusion

Determination of heavy and toxic metals concentrations in instant food products is important for health risk assessment during food consumption. This kind of study can be used as a tool for the manufacturers so that they may adopt such strategies which lead them to save the population by minimizing the problems related to the metal toxicities. Such assessment for the contaminations is required for the well-being of the population. The overall study suggests that the long-term consumption of instant foods can cause potential health risks to consumers.

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