The Myanmar Health Sciences Research Journal, Vol. 21, No. 2, 2009

Lead contamination of common Myanmar foodstuffs prepared/ stored in ceramic glazed potteries

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Possible contamination of lead in common Myanmar foodstuffs prepared/ stored in glazed potteries (GP) was studied by measuring the lead concentration and pH of them before and after the storage/preparation in glazed potteries. The findings were compared with those which were prepared/stored in lead free plastic containers. Before the storage, all the food samples except Ngan-pyar-ye (fish sauce) were not found to have detectable lead content by atomic absorption spectrophotometer. After the storage/preparation in GP their lead levels ranged from 0.5 to 17.1 mg/kg (wet weight) with the pH range of 3 to 6. Lead levels of the control samples were non-detectable, except Ngan-pyar-ye which was previously contaminated. Mean lead contents of 4% acetic acid stored in GP were 23.1, 29.0, and 30.8 mg/kg (ppm) on day 1, 2, and 3, respectively.

INTRODUCTION

The fact that lead-glazed pottery could result in poisoning was known in antiquity and fermented liquors stored in these containers as a source of lead poisoning have a long story [1]. In the second and first century BC wine was stored in the earthenware and drinking of it by aristocratic women have resulted in chronic lead poisoning and sterility. It may have well contributed to the rapid extinction of the aristocratic class. From this reasoning lead poisoning has been alleged to have contributed to the fall of the Roman Empire [2, 3].

Various authors in 1919 investigated earthenware containers and showed that when they were used for storing or cooking food containing malic or citric acids, these plumbo-solvent acids could lead to serious contamination of foodstuffs with lead [4]. The contribution of food to man's exposure to lead has been under study for many years beginning with the study of Kehoe *et al.* [5, 6, 7] in 1933, who found lead in every item of food in both industrial and primitive societies. The fact that the amount of lead leached from glazed and enamelled foodware in contact with foodstuffs are dependent on inter alia the composition of the glaze/enamel, the firing conditions, pH of the food and lead-glazed utensils has been noted [8, 9, 10]. The United States Potters' Association and the United States Food and Drug Administration have defined 7 ppm as the maximum lead release of glazes recommended for use on ceramic items [11].

Knowing the importance of lead exposure from foodstuffs "Joint FAO/WHO Expert Committee on Food Additives (JECFA)" recommended in 1972 that for adults, the intake of lead via the diet should not exceed 3 mg/week which is equivalent to about 50 µg/kg body weight per week [4, 11].

In Myanmar, many foodstuffs like Hmyin-ngapi (fish paste), Ngapi-ye-cho (fermented fish), fermented vegetables etc. are

prepared/ stored in ceramic glazed pottery. These foodstuffs are widely eaten by our people and no study has ever been done on the lead levels of these foodstuffs. The main purpose of the present study was to determine the lead contamination of common foodstuffs in order to highlight the deleterious effect of storing/preparing foods in ceramic glazed pottery.

MATERIALS AND METHODS

Hmyin-ngapi (fish paste), Ngapi-ye-cho (fermented fish) and Ngan-pyar-ye (fish sauce) were bought from the Government shops, where they were not stored in glazed pottery. Equal amount of each item were stored in glazed pottery (GP) and lead free plastic containers (LFPC). Their pH and lead levels were measured (in duplicate samples) before and 2 and 4 weeks after the storage.

Fresh vegetables: Monnyin (mustard green), Pepin-pauk (sprouted beans), Ga-zun-ywet (water green) and fresh fruits: Da-nyin-thee (apes earing) and Shauk-thee (lemon) were bought from the bazaar for fermentation. Fermented rice water was prepared first and equal amounts were placed in the different containers. About 50 gm each item of vegetables were then put into each type of container separately. Lead levels of fresh rice water and common salt (used in fermentation) were measured before the fermentation. Only 1.8 mg of salt was added to 100 gm of food. One litre of rice water was placed in each container. pH and lead levels of the food items in each container (in duplicate samples) were measured before and 2 and 4 days after the storage (when they were in the condition to be consumed).

Kyan-ma-saing (fermented mustard green) was prepared and stored the same as above but the pH and lead levels were measured before and 5 and 7 days after the storage (when they were in the condition to be consumed). Salted apes earring and lemon were also prepared as above except that fermented water was not included. The same amount of salt was used for the preparation. pH and lead levels (in duplicate samples) were measured before and 2 and 4 weeks after the storage (when they were in the condition to be consumed). The afore-mentioned common Myanmar foodstuffs that were already prepared/ stored in glazed pottery were also bought from the randomly selected 4 bazaars. Again the samples were bought at random in a way a consumer might choose such products. Their wet weight, pH, and lead levels were measured. Four per cent acetic acid solution was filled to the top of the different containers as a testing procedure for lead leaching [1]. For each type of container, a number of three were treated with 4% acetic acid and stored for 3 days. Lead levels and pH values were determined each day.

Determination of lead level by the atomic absorption spectrophotometer (AAS)

Solid foodstuffs

Pre-weighted wet samples were dried in the oven. Dry weights of the samples were measured also. They were ashed in a temperature-programmed furnace. The temperature was gradually increased from ambient to 450°C . The ash was moistened with water and the water was then evaporated on a hotplate prior to re-ashing. This procedure was repeated until the wet ash was completely free from visible carbon particle. The ash was then dissolved in 5 ml of concentrated hydrochloric acid. The solution was evaporated to dryness and the residue was finally dissolved in 100 ml of distilled water.

Lead levels were then analysed by AAS (Pye UNicam SP 9) with background correction. It was determined at 217 nm with an oxidising air-acetylene flame. The precision and accuracy were checked by analysing 3 standard solutions. The sensitivity of the AAS was 0.1 ppm.

Liquid foodstuffs

The samples were filtered before being

introduced into the AAS. Lead levels were analysed as above.

pH measurement

Pre-treated fluid samples were measured by pH meter and the solid samples were measured by using the pH paper.

RESULTS

Table 1 shows the lead levels and pH values of common Myanmar foodstuffs before and after storage/preparation in GP or LFPC. Before storage, lead levels of all the food items under study were non-detectable (<0.1 mg/kg wet weight) except fish sauce which had 3.03 mg/kg (3.03 ppm). The pH values of fish paste, fermented fish and fish sauce were 6 and those of other food items ranged from 3 to 4. Seven food items were selected for preparation/storage, which were supposed to be the most commonly consumed. Those stored in LFPC were found to have non-detectable lead levels after a month's storage (4 weeks) with the exception of fish sauce, which was contaminated with lead prior to storage. But its lead level did not rise with storage in LFPC.

Table 1. Lead levels of common Myanmar food stuffs before and after storage or preparation in glazed pottery and plastic containers

Food item	pH	Lead content (mg/kg)				
		Before storage	After storage			
			Glazed pottery (GP)		Plastic container (LFPC)	
			2 weeks	4 weeks	2 weeks	4 weeks
Hmyin-ngapi (Fish paste)	6	ND	4.5*	5.9*	ND	ND
Ngapi-ye-cho (Fermented fish)	6	ND	4.2*	5.2*	ND	ND
Ngan-pyar-ye (Fish sauce)	6	3.03	4.1*	4.7*	3.03	3.03
Da-nyin-thee (Apes earring)	4	ND	0.5	1.2	ND	ND
Shauk-thee (Lemon)	3	ND	10.4*	17.1*	ND	ND
Fermented vegetables	3.3	ND	5.2* (2days)	6.3* (4days)	ND	ND
Monnyin (Mustard green)	4	ND	4.9* (3days)	5.8* (7days)	ND	ND

ND = Non-detectable

* = More than permissible level

Those samples stored in GP contained more than maximum permissible level (2 mg/kg, Codex Alimentarius) except for salted Da-nyin-thee (0.5 mg/kg). Lead level of fish sauce increased from its pre-storage level. It was also found that lead levels increased with longer duration of storage. Salted lemon, which had lowest pH of 3.0 had highest lead level.

In Table 2, lead levels in similar food items obtained from randomly selected 4 bazaars in Yangon are presented. Duration of storage for fish paste, fermented fish, and fish sauce was informed to be whole year round. With the exception of fish sauce, lead levels of the rest two items were higher than our laboratory samples stored in GP. The lead levels in salted and fermented foodstuffs as above, purchased from the randomly selected bazaars are also shown in Table 2. Their pH values were similar to those of our laboratory samples. They were also contaminated with lead although the lead levels ranged within the permissible limit (i.e. highest limit irrespective of the nature of the food (2 mg/kg) except one fermented mustard green sample from Hlaing Township bazaar. The results of lead leaching tests for different containers are presented in Table 3. From the GP large amount of lead was leached (well above the maximum permissible concentration of 7 ppm). Even in the GPs the amount of lead leached varied widely. Leaching increased with longer contact with acetic acid.

Table 2. Lead level in common Myanmar food-stuffs from bazaars

Food Item	pH Mean ± SD (range)	Lead content (mg/kg) Mean ± SD (range)
Hmyin-nga-pi	5.3 ± 0.5 (5-6)	6.9 ± 0.6 (6.3-7.6)*
Ngapi-ye-cho	4.8 ± 0.5 (4-5)	6.9 ± 0.3 (6.5-7.2)*
Ngan-pyar-ye (Fish sauce)	5.8 ± 0.5 (5–6)	3.9 ± 0.3 (3.4-4.1)*
Salted Da-nyin-thee	4.1 ± 0.03 (4.0-4.1)	1.1 ± 0.5 (0.5-1.7)
Fermented vegetables	4.0 ± 0.10 (3.9-4.1)	1.0 ± 0.4 (0.6-2.1)
Monnyin (Mustard green)	4.1 ± 0.10 (4.0-4.3)	1.4 ± 0.7 (0.6-2.1)

*= More than maximum permissible level

Table 3. Lead levels in 4% acetic acid solution after storage in glazed pottery/ plastic containers

Type of container	Duration of storage (hrs)	pH	Lead content (ppm)
Glazed pottery			
No.1	24	2.6	42.6*
	48	2.6	54.4*
	72	2.6	55.8*
No.2	24	2.6	8.7*
	48	2.6	12.5*
	72	2.6	14.6*
No.3	24	2.6	17.7*
	48	2.6	20.2*
	72	2.6	22.0*
Plastic			
No.1	24	2.6	ND
	48	2.6	ND
	72	2.6	ND
No.2	24	2.7	ND
	48	2.7	ND
	72	2.7	ND
No.3	24	2.6	ND
	48	2.6	ND
	72	2.6	ND

ND = non-detectable

* = more than maximum permissible level (7 ppm)

Table 4. Maximum permissible lead levels of foods (Codex Alimentarius, 1999)

Maximum lead level (mg/ kg)	Food
0.1	*Edible oil* : soyabean oil, sunflower seed oil, sesame seed oil, etc. lards, rendered pork fat, margarine
0.1 TE	*Edible oil* : coconut oil, palm oil, palm kernel oil, etc.
0.3 UR	*Juices* : orange, apple, tomato, grape, grape-fruit, etc.
0.3	Conc. pineapple juice with preservative
0.5	Cocoa butters
0.5 TE	Canned bouillon and consomme, fructose
1.0	Chocolate, composite and filled chocolate
1.0 UR	Lemon juice preserved exclusively by physical means
1.0 TE	White sugar, bouillon and consomme (in dry product), powdered sugar, soft sugar, glucose syrup, lactose, etc.
2.0 TE	Cocoa nibs, cocoa mass, cocoa press cake, cocoa dust, cocoa powder and dry cocoa-sugar mixtures
2.0	Edible acid casein, edible caseinates

Table 4 shows the maximum permissible levels of lead in foods adopted by the Codex Alimentarius, JECFA in 1999 [11]. The values are expressed in mg/kg wet weight. Although the nature of the food items are different from our common Myanmar foodstuffs it can be used as a guideline. The maximum permissible levels ranged from 0.1 to 2 mg/kg depending on the nature of the food.

Lead level in rice water was non-detectable but that in common salt was found to be 1.78 mg/kg (not shown in the tables). Although common salt was used for fermentation and salting fruits, the amount added was too low (only 1.8 mg/100 gm of food) that it would not change the lead level of food to any appreciable degree.

DISCUSSION

Lead leaching from the glazed pottery in contact with acidic food or drink have been noted in the past and actually as far back as the time of the Roman Empire [2]. Klein *et al.* in 1970 [1] reported 2 cases (one fatal) of lead poisoning in which apple juice (pH 2.6) stored in the incriminated vessel for 3 days contained 1300 mg/l. There were numerous findings of lead poisoning cases due to drinking of wine stored in earthernware vessels [1, 9, 10]. The amount of lead leached depends on the composition of the glaze, the firing conditions, pH of the food, and the temperature [8].

In our study, lead levels in Myanmar foodstuffs before storing or preparing in the glazed pottery were non-detectable (less than 0.1 mg/kg), except for fish sauce which contained 3.03 mg/kg (ppm). According to the seller, fish sauce was stored in cemented brick tanks in the factory.

Experimental study in our laboratory showed that all the food items, which were stored/prepared in GPs were contaminated with lead. Lead level of fish sauce increased after the storage. Even the food items whose pH was quite high had high lead content, more than the maximum permissible concentration of 2 mg/kg. Only the salted apes earring had lead level within the permissible range. Food item with lowest pH (pH 3), salted lemon had highest lead level, the

finding of which is in accord with those of the other studies. The more acidic the substance, the more lead would be leached [8]. Lead levels of food items with higher pH were comparable to those of fermented vegetables, which had lower pH values. It was because fish paste etc was stored for longer duration (2 to 4 weeks) than fermented vegetables (2 to 7 days only). This finding indicates that lead leaching increased with longer duration of storage.

Fermented vegetables and mustard green from the consumer's bazaars contained lead levels which were much lower than that of the similar food items of our laboratory probably because we used the new containers while in bazaars the containers were used in repetition. Duration of storage was similar in both cases. Salted apes earing on the other hand contained the comparable lead levels both from bazaar and our laboratory. It cannot be explained because the actual duration of storage from the bazaar sample was not known. Fish paste, fish sauce and fermented fish from bazaar had higher levels although they used the same container repeatedly, probably because they stored these foodstuffs for one whole year round while we stored our samples for only 4 weeks.

There is no documented evidence of acute lead poisoning by eating of acidic foods stored/prepared in glazed pottery in our country although chronic low level exposure cannot be excluded. It can be explained by the fact that although there was some amount of lead contamination, the food-stuffs were not acidic enough to cause excessive leaching of lead like those seen in wine and apple juice etc from the foreign countries whose pH values were below 3. Ours were all above pH 3 except for salted lemon, which had pH 3. But this does not refute the well-documented fact that storing or preparing acidic foodstuffs in glazed pottery is dangerous. There is still some amount of lead contamination, even exceeding the maximum permissible level in some of the common Myanmar foodstuffs which can give rise to chronic low level lead exposure. From our study, consuming fish paste, fermented fish and fish sauce is more dangerous than eating fermented vegetables.

ACKNOWLEDGEMENT

We would like to express our deep gratitude to the Director-General, Department of Medical Research, (LM) for allowing us to carry out this study and to the staff of Nutrition Research Division, DMR (LM) for their kind co-operation.

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