Detection and Survey of Heavy Metals Residues in Infant Formulas and Condensed Milk

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ABSTRACT

A total of 60 samples of infant formulas include (ready to use and powdered milk based formulas), infant milk and condensed milk (15 samples each), were collected randomly from Zagazig City supermarkets and pharmacies. The collected samples were analyzed for detection of aluminum, tin, copper and manganese using Atomic Absorption Spectrophotometer. The average of aluminum in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk were 2.87 ± 0.08, 1.5±0.02, 2.16±0.16 and 0.11±0.01 (ppm) respectively. On the other hand, the mean values of tin in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk were 0.89±0.30, 0.42±0.10, 1.8±0.16 and 1.34±0.41 (ppm) respectively. Meanwhile, the average of copper in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk were 0.58±0.23, 2.90±0.75, 0.72±0.02 and 0.19±0.02 (ppm) respectively. Manganese levels in all examined samples were high in comparison with the permissible limits. The public health hazard and sources of contamination by heavy metals (AL and Sn), and the changes in essential elements (Cu and Mn) were discussed.

INTRODUCTION

We have recently become more and more aware to the problems of the pollution. Both government and industries have begun to take steps to avert further deterioration of our surrounding environment. However, the situation is already so grave, particularly on the local level that the controllable measures for pollution might not show any positive effects in the near future. The pollution in air, soil and water has been become serious matter, since the pollutants found their way into the food chain and reached to the body resulting in harmful effects *(1)*.

Environmental pollutants play an important role in development of several diseases in human being specially in children, where they are more sensitive to pollution. Heavy metals are among the most dangerous forms of pollutant that may contaminate a food source by leaching process between food and its container *(2)*.

Furthermore, residues of heavy metals in food have a role in animal and human health, so they are important and interesting to distinguish between the harmful effect on health due to trace amount present in food and perimssible limits or nutritional requirements of these element known to be essential to human and animal life *(3)*. In contrast, the presence of these metallic elements at a higher rate to be able to induce either some cellular disturbances or clinical manifestation *(4,5,6)*.

The toxic metals which considered of major interest in food safety are aluminum and tin. These metals are of recognized toxicity and their presence in food at significant concentrations is a potential health hazard. Copper and manganese are considered as nutrients and are essential in biological procese as activator of certain enzymes or indirectly as essential components of vitamins or hormones, and when they are given in excess amount, they become toxic *(7)*.

Aluminum toxicity is well recognized as an common factor in many clinical disorders, the most prominent being Alzheimer's disease *(8)*. It is also associated with the metabolism of bone phosphate *(9)* and complications in dialysis dementia and some forms of sclerosis *(10)*. The toxic effects are serious in infants because the immature gastrointestinal tract of an infant may be more permeable to aluminum than that of an adult *(11)*.

High level of tin in food can cause acute poisoning and the fatal toxic dose for human being 5-7 mg / kg / body weight, also the chronic tin poisoning manifested in growth retardation, anemia, histopathological change in liver and influence iron absorption and hemoglobin formation. However dietary tin has been shown to interfere with the metabolism of certain elements *(12)*.

Manganese is one of certain chemicals that are capable of causing permentant brain damage and chronic manganese has been reported among manganese miners in Latin America, the effect is similar to idiopathic or post encephalitic parckinsonism *(13)*.

Copper occurs in foods in many chemical forms and combinations which affect its availability to the animal. Repeated copper exposures has been associated with haemolytic anemia *(14)*. The dairy products, white sugar and honey are considered the poorest sources of copper, which rarely contain more than 0.5 ppm *(15)*.

Because of greater sensitivity of young children to toxic substances present in the diet and their primary dependence on this item in their diets, this study was under taken to throw light on the level of some heavy metals and essential elements in baby food and to evaluate their hygienic condition.

MATERIAL AND METHODS

Collection of samples

Sixty samples of infant formulas include (ready to use and powdered milk based formulas), infant milk and condensed milk (15 samples each) were collected randomly from Zagazig city supermarkets and pharmacies, Egypt and transferred to the laboratory in their packages.

Estimation of metals

The level of aluminum, tin, copper and manganese were estimated using atomic absorption spectrophotometer AAS. The absorption and concentration were recorded directly from the digital scale of AAS. Standard procedures were used to estimate aluminum, copper, manganese and tin in the examined samples *(16)*.

RESULTS

Table 1. The level of heavy metals and trace elements in examined samples (ppm).

Metal / Product	AL			Sn			Cu			Mn		
	Min	Max	Mean ±S.E	Min	Max	Mean ±S.E	Min	Max	Mean ±S.E	Min	Max	Mean ±S.E
M.B.F* ready to use	0.38	3.52	2.87±0.08	0.07	2.10	0.89±0.30	0.13	1.53	0.58±0.23	0.02	0.18	0.09±0.07
M.B.F. powdered	0.10	2.00	1.50±0.02	0.20	0.73	0.42±0.10	0.27	4.72	2.90±0.75	0.43	3.13	1.90±0.69
Infant milk	0.93	4.02	2.16±0.16	0.16	2.30	1.80±0.16	0.20	1.50	0.72±0.02	0.35	1.05	0.51±0.05
Condensed milk	0.02	0.30	0.11±0.01	0.46	2.80	1.34±0.41	0.07	0.45	0.19±0.02	0.04	0.20	0.08±0.01

* M.B.F. = Milk based formula

Table 2. Frequency distribution of heavy metals and trace elements in examined samples.

Metal	P.L.* (ppm)	M.B.F** ready to use (n=15)				M.B.F powdered (n =15)				Infant milk (n=15)				Condensed milk (n=15)			
		Within P.L		Over P.L		Within P.L		Over P.L		Within P.L		Over P.L		Within P.L		Over P.L	
		No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
AL	0.06(a)	6	40	9	60	5	33.3	10	66.7	4	26.7	11	73.3	5	33.3	10	66.7
Sn	<0.2(b)	5	33.3	10	66.7	8	53.3	7	46.7	2	13.3	13	86.7	3	20	12	80
Cu	0.1-5.0(c)	6	40	9	60	3	20	12	80	5	33.3	10	66.7	6	40	9	60
Mn	0.04-0.07(d)	4	26.7	11	73.3	6	40	9	60	6	40	9	60	3	20	12	80

a: (17) b: (18) c: (19) d: (20) * P.L = Permissible limit ** M.B.F = Milk based formula

Table 3. Comparison of acceptable daily intake (ADI) value of heavy metals and trace elements with the calculated daily intake from examined samples.

Metals	ADI(a) mg/70 kg / person	Mean concentration of metal mg/L in				Calculated daily intake of metals from consumption of 100 gm/per day (b)							
		M.B.F* ready to use	M.B.F powdered	Infant milk	Condensed milk	M.B.F* ready to use		M.B.F powdered		Infant milk		Condensed milk	
						µg/day / person	%	µg/day / person	%	µg/day / person	%	µg/day / person	%
AL	12	2.87	1.50	2.16	0.1	0.287	2.40	0.150	1.25	0.216	1.8	0.011	0.09
Sn	3	0.89	0.42	1.80	1.34	0.089	2.97	0.042	1.4	0.18	6	0.134	4.47
Cu	35	0.58	2.90	0.72	0.19	0.058	0.17	0.29	0.83	0.072	0.205	0.019	0.05
Mn	5	0.09	1.90	0.51	0.08	0.009	0.18	0.190	3.8	0.051	1.02	0.008	0.16

a: (21) b: (22) ** M.B.F = Milk based formula

DISCUSSION

During the last years, great deals of environmental researchers are directed towards environmental pollution with heavy metals which are persistent contaminants in the environment and come to the forefront of dangerous substance causing serious hazard in both animal and human. Industrial and agricultural use of heavy metals and their compounds resulted in environmental pollution and presence of metal residues in all levels of food chain *(23)*.

The obtained results recorded in table (1) revealed that the mean concentration of aluminum in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk were 2.87±0.08, 1.50±0.02, 2.16±0.16 and 0.11±0.01 ppm respectively.

The highest aluminum level was detected in ready to use milk based formula followed by infant milk, these result in comparison with permissible limit in infant formulas and milk (0.05 and 0.5 ppm respectively as stated by *(17)* were higher in ready to use milk based formulas and infant milk but within the normal level in powdered milk based formulas and condensed milk.

The ready to use milk based formulas, powdered milk based formulas and condensed milk contained 0.18, 1.37 and 0.08 µg/gm of aluminum *(24)* which was lowered than that obtained in our study while lowering aluminum level in infant milk was reported by *(25)*.

From the previously mentioned results it can be concluded that aluminum was detected with high level in examined samples which may be attributed to general possibilities of extensive use of aluminum from saucepan or food packing into food stuffs, as will as drinking water. Electrochemical erosion when food are left in contact with aluminum vessels for long periods, the acidic and salty foods can increase the concentrations of complexing ions ***(26).***

The obtained results revealed that the mean concentration of tin in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk were 0.89±0.30, 0.42±0.10, 1.8±0.16 and 1.34±0.41 ppm respectively. Highest tin level detected in infant milk followed by condensed milk. The obtained results were nearly similar to that reported by ***(24, 25).***

The maximum permissible limit of tin reported by ***(18)*** was <0.2 mg/kg. The high level of tin may be due to the nature of tinned cans manufacture (their composition tin 98.8%) capable of participating in electrochemical transformation ***(27).***

Tin toxicity has been extensively investigated, especially in small quantities in experimental animals. High level of tin in food can cause acute poisoning. However, there appear to be considerable individual variation in response to dose of tin ***(12).***

The copper levels in the present study were 0.58±0.23, 2.90±0.75, 0.72±0.02 and 0.19±0.02 in the ready to use milk based formula, powdered milk based formulas, infant milk and condensed milk respectively. These findings were lowered than that reported by ***(28)*** and considerably didn't differ from that of ***(24).*** While low copper levels were recorded by ***(29).***

The maximum permissible limits of copper in milk and dairy products ranged from 0.1 to 5.0 mg/kg, the high level in powdered milk based formulas may be due to supplemental copper as cow's milk low in copper ***(19).***

Copper is an essential element having roles in formation of erythrocyte, release of tissue iron and development of bones, CNS and connective tissues. Moreover, it is an important constituents of different enzyme system in both man and animals. The major sources of copper in the diet are cereals, fruit and vegetables while milk contains little copper, usually less than 0.1 mg / kg ***(30).*** Copper in high concentration is poisonous to both man and animals ***(31).***

Our result revealed that the mean values for manganese were 0.09±0.07, 1.90±0.69, 0.51±0.05 and 0.082±0.01 in ready to use milk based formulas, powdered milk based formulas, infant milk and condensed milk respectively.

Nearly similar results, were obtained by ***(24)*** in milk based formulas and condensed milk while high manganese level in infant milk was cited ***(32).*** High manganese levels were obtained in our study in comparison with the permissible limit of manganese (0.04-0.07 ppm) ***(20).***

Manganese in human milk is found mostly in the whey whereas in cow's milk it is present primarily in the casein fraction ***(33).*** Manganese can be found in dairy products in different concentrations, where its value in cow's milk ranged from 10 to 50 mg/L***(34).*** Manganese is important in human nutrition and metabolism, but human milk is poor source of manganese.

CONCLUSION

As the heavy metals are considered the main toxic by-products causing serious health hazard to human and animal populations through progressive irreversible accumulation in their bodies as a result of repeated consumption of small amounts of these elements. In order to avoid possible toxic injuries in human, specially infants and children, industry should certainly pay more attention both in supplying and in technological management of milk and its products.

REFERENCES

1- ***Protasowizki, M. (1992):*** Heavy metals content in the selected food. 3rd World Congress of Food Borne Infections and Intoxication, 16-19 June, Berlin.

2- ***Hagstad, H.V. and Hubbert W.T. (1986):*** Food Quality Control. In : Foods of Animal Origin. Pp. 86-87. The Iowa State University Press Ames.

3- ***Crosby, N.T. (1977):*** Determination of metals in foods. A review J. The Analyst., 102 (12): 1213.

4- ***Fribrg, L. and Elinder, C.G. (1988):*** Cadmium toxicity in Human: Essential and trace elements in human health and disease. Edited by A.S. Prasad (New York, A.R.-Liss) 559-587.

5- ***Krishnan, S.S.; Melachland, D.R.; Dalion, A.J.; Krishnan, B. and Kruck, T. (1988):*** Aluminum toxicity in human. Essential and toxic trace elements in human health and disease. Edited by A.S. Prasad (New York; A.R. Liss) 645-659.

6- ***Skerfving, S. (1988):*** Toxicity of inorganic lead. Essential and toxic trace elements in human health and disease. Edited by A.S. Prasad (New York, A.R. Liss) 611-630.

7- ***Contharow, A. and Schsport, Z.B. (1977):*** Biochemistry. 6th Ed., Saunder B.W.Co., Philadelphia, USA.

8- ***Cowburn, J.D.; Farrar, G. and Blair, J.A. (1990):*** Alzheimer's disease-some biochemical clues. Chem. Britain, 26 : 1169-1173.

9- ***Lione, A. (1983):*** The prophylactic reduction of aluminum chem. 35: 197-208.

10-***Gruskin, A.B. (1988):*** Aluminum : a pediatrics overview. Advance Pediatr., 35, 281-330.

11- ***Sedman, A.B.; Klein, G.L.; Merritt, R.J.; Muler, K.D.; Weber, W.; Gua, W.L.; Anand, H. and alfery, C. (1985):*** Evidence of aluminum loading in infants receiving intravenous therapy. N. Engl. J. Med. 312: 1337.

12- ***Reilly, C. (1991):*** Metal contamination of food. 2nd ed. Elseiver Applied Science, London.

13- ***Bender, A.E. (1984):*** Nutrition in Food Industries Manual, 21st Edition. Ranken M.D. (ed.) PP. 375, Leonard Hill, USA.

14- ***Manzler, A.D. and Schereiner, A.W. (1970):*** Copper-induced acute hemolytic anemia. A new complication of hemodialysis. Ann. Intern. Med., 73: 409-412.

15- ***Underwood, E.J. (1977):*** Trace Elements in Human and Animal Nutrition. 4th Ed. Academic Press, New York, San Francisco, London.

16- ***Agemain, H.; Sturtevant, D.P.; Epivatianos, P. and Nathanael, B. (1980):*** Simultaneous-extraction of six trace metals from fish tissue by hot digestion and determination by atomic absorption spectrophotometer. Analst. 105-125.

17- ***Pennington, J.A. (1987):*** Aluminum content of foods and diets. Food Add. Contam., 5: 161-232.

18- ***Sherlock, J.C. and Smart, G.A. (1984):*** Tin in food and the diet. Food Add. Cotnam., 1: 277-282.

19- ***Lonnerdal, B.; Kletn, C. and Hurley, L. (1981):*** Iron, copper, zinc and manganese in milk. Annual Review of Nutrition, 1 : 149-174.

20- ***Wenlock R.W.; Buss, D.H. and Dixon, E.J. (1979):*** Trace Nutrients 2-Manganese in British Foods. Br. J. Nutr., 41: 253-61.

21- ***FAO / WHO (1989):*** Joint Expert Committee on Food Additives, WHO Technical Report Series No. 505.

22- ***Nutrition Institute (1996):*** Guide of Healthy Food for Egyptian Family. 2nd ed. Nutrition Institute. Cairo, A.R.E.

23- ***Tork, I.Y. (1996):*** Environmental heavy metal hazard in relation to animal health. Project Proposal Fac. of Vet. Med., Zagazig University, Egypt.

24- *Robert, W.D. and Arthur, D.M. (1992):* Graphite-Furnace atomic absorption spectrometric dtermination and survey of total aluminum, copper, manganese, Molybdenum, and tin in infant formulas and evaporated milks. J. A.O.A.C. International, 75 (6): 954-963.

25- *Enas, M.S. (2005):* Studies on heavy metals content in market milk in Sharkia Governorte. Ph. d. Thesis, Fac. Vet. Med., Zagazig University.

26- *Mei, L. and Yao, T. (1994):* aluminum contamination of food from using aluminum ware. Internatioanl J. Environ. Anal. Chem. 50 (1): 1.

27- *Arvanitoyannis, I. (1990):* The effect of storage of canned juices on content of the metals Fe, Cu, Zn, Pb, Sn, Cd, AL, and in Nahrung, 34: 141-145.

28- *Madeha, A.A. (2002):* Trace elements in some dairy Products. Alex. J. Vet. Sci., 18 (1): 11-15.

29- *Enas, E. and Manal, A. (2001):* Estimation of some metallic pollutants in dried weaning baby foods. Assiut Vet. Med. J. 45 (90): 166-177.

30- *Crosby, N.T. (1991):* Determination of veterinary residues in food. Eliss Horwood, Great Britain.

31- *Pearson, D. (1976):* The chemical analysis of food. Churchill Livingston, London.

32- *Khaled, A.A. and Eman, K. (2001):* Lead, cadmium and manganese in milk and some milk products in upper Egypt. Assiut Vet. Med. J. 45 (89): 336-348.

33-*Fairweather-Tait, S.J. (1992):* Bioavailability of trace elements. Food Chemistry (43): 213-217.

34- *Koops, J. and Westerbeek, D. (1993):* Manganese in dutch powder. Determination by Zeeman-corrected stabilized-temperature plate form. Furance atomic-absorption spectorscopy. Neth. Milk, Dairy J. 47: 1-13.

الملخص العربى

البحث والكشف عن بقايا المعادن الثقيلة فى ألبان الأطفال واللبن المكثف

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أجريت الدراسة علي ستون (٦٠) عينة من أغذية الفطام التى تعتمد في تصنيعها علي الألبان منها المعدة للاستخدام ومنها البودرة الجافة بالإضافة إلى ألبان الأطفال الجافة واللبن المكثف وقد تم تجميع العينات عشوائيا بمعدل (١٥) عينة من كل نوع من المحلات الكبرى والصيدليات فى مدينة الزقازيق. تم تحليل العينات باستخدام جهاز الامتصاص الذري لتقدير مستوى كل من الألومنيوم والقصدير والنحاس والمنجنيز.

أظهرت النتائج وجود الألومنيوم لمتوسط ٢,٨٧ ±٠,٠٨ ، ١,٥ ±٠,٠٢ ، ٢,١٦ ±٠,١٦ و ٠,١١ ±٠,٠١ فى أغذية الفطام المعدة للاستخدام والبودرة الجافة وألبان الأطفال الجافة واللبن المكثف علي التوالي.

وكانت نسب تواجد القصدير ٠,٨٩±٠,٣ ، ٠,٤٢±٠,١ ، ١,٨±٠,١٦ و ١,٣٤ ±٠,٤١ فى أغذية الفطام المعدة للاستخدام والبودرة الجافة وألبان الأطفال واللبن المكثف.

بينما تواجد النحاس فى العينات السابق ذكرها بمتوسط ٠,٥٨±٠,٢٣ ، ٢,٩±٠,٧٥ ، ٠,٧٢±٠,٢ و ٠,١٩±٠,١٢ علي التوالي.

كما لوحظ تواجد المنجنيز بتركيزات أعلى من الحدود المسموح بها عالميا. ومما سبق يتضح مدى خطورة ارتفاع نسب المعادن الثقيلة فى أغذية وألبان الأطفال والتي قد تسبب أضرارا صحية بالغة على صحة الأطفال.