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LEAD LEVELS AND DISTRIBUTION IN MILK AND SOME MILK PRODUCTS

(With 3 Tables and 2 Figures)

By

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مستويات الرصاص وانتشاره في اللبن الخام وبعض منتجاته

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أصبحت مشكلة تلوث البيئة قضية خطيرة تشغل العالم اليوم وكذلك القائمين على صحة الإنسان ، لأن التلوث امتد ليشمل الماء والهواء والتربة وما يخرج منها من نبات يتغذى عليه الإنسان والحيوان. وقد نجم عن هذا أضراراً بالغة الخطورة لحقت بالإنسان والحيوان نتيجة تناول هذه الأغذية الملوثة . ويعتبر التلوث بالمعادن الثقيلة وخاصة الرصاص من أخطر أنواع التلوث لما له من أثر على الجهاز العصبي والدم وكذا تأثيره المباشر على مستوى الذكاء وبخاصة في الأطفال . لذا وجب الاهتمام بفحص الأغذية لتقدير معدل تواجد الرصاص لما يتميز به من أثر تراكمي حتى يمكن تجنب أخطاره قبل وصول هذه الأغذية للمستهلك. تم في هذه الدراسة جمع ستين عينة بصورة عشوائية من اللبن الخام ومنتجاته المعدة للاستهلاك والتي تباع بمدينة أسيوط بواقع عشرة عينات من كل نوع خلال عام ٢٠٠٠م لمعرفة معدل تواجد الرصاص وتحديد مستوياته ومقارنتها بالمعدلات المصرية والعالمية المسموح بها في هذه الأغذية. كذلك استهدفت الدراسة معرفة مدى انتشار الرصاص في منتجات الألبان بعد تصنيعها من لبن ملوث بهذا العنصر وذلك بإضافة خلات الرصاص إلى اللبن الخام بمعدل ١,٥ مجم/لتر ثم تم تصنيعه إلى قشدة وزبد وجبن قريش ودمياطي وزبادي. وقد تبين من النتائج أن متوسط تركيز الرصاص بلغ ٠,٣٢٤ ± ٠,١١٧ ، ٠,٣٤٨ ± ٠,٠٨ ، ٠,٣٢٨ ± ٠,٠٤٨ ، ٠,٨٥٩ ± ٠,١١٤ ، ٠,٤٦٨ ± ٠,١٢٦ و ٠,٣٥٣ ± ٠,١٣٢ جزء في المليون في عينات كل من اللبن الخام والقشدة والزبد والجبن القريش والدمياطي والزبادي على التوالي والتي جمعت بصورة عشوائية من مدينة أسيوط. كما دلت النتائج أن ٣٠ ، ٢٠ ، ٢٠ ، ٤٠ ، ٣٠ ، و ٣٠% من إجمالي العينات السابقة والتي تم تحليلها للرصاص قد تعدت الحد الأقصى المسموح به عالميا (٠,٢ جزء في المليون). وطبقاً للمواصفة القياسية المصرية للرصاص في الجبن الطري قليل الدسم ، فأن ٦٠% من عينات الجبن القريش المفحوصة قد تعدت الحد المسموح به والذي يبلغ ٠,١ جزء في المليون. ويتضح من ذلك أن الجبن بنوعيه القريش والدمياطي احتوى على التركيزات

الأعلى من الرصاص. ودلت نتائج الدراسة في جزئها الثاني على أن الرصاص تركز في الجبن بنوعيه القريش والدمياطي بمعدل بلغ من ثلاثة إلى أربعة أمثاله في اللبن الخام وإن احتوى الجبن الدمياطي على التركيز الأعلى وكذلك في القشدة والزبد نسبة إلي تركيزهما في اللبن الخام. أما الزبادي فلم يختلف تركيز الرصاص به عن اللبن الخام كثيراً. وأوضحت النتائج أن شرش الزبد والذي نتج عن تصنيع الزبد قد احتوى على كمية عالية وملحوظة من الرصاص ، الأمر الذي يجب أن يؤخذ في الاعتبار عند تصنيع اللبن الملوث بالرصاص. ويتبين من هذه النتائج أنه بالرغم من ارتفاع معدل الرصاص في الألبان المفحوصة إلا أنها لا تمثل خطراً كالذي ينبغي أن ننتبه إليه من تصنيع هذه الألبان إلى منتجات يتركز فيها الرصاص. ولذا ينصح بأنه إذا كان لزاماً استخدام الألبان الملوثة فليكن بحذر شديد ، ناهيك عن تصنيعه إلى جبن خاصة إذا أخذنا في الاعتبار الدور الهام الذي يلعبه الهواء والماء بجانب الأغذية الأخرى كمصادر مختلفة في زيادة هذا الملوث. ولقد ناقشت الدراسة المخاطر الصحية للرصاص علي مستهلكي هذه الأغذية وكذلك الاحتياطات اللازمة لتجنب هذه المخاطر.

SUMMARY

Lead levels in sixty samples of raw milk, cream, butter, kareish and damietta cheese and yoghurt (10 samples each) that randomly collected from different localities in Assiut City were estimated using atomic absorption spectrophotometer. The mean lead levels in the examined milk, cream, butter, kareish and damietta cheese and yoghurt samples were 0.324 ± 0.117, 0.348 ± 0.080, 0.328 ± 0.048, 0.859 ± 0.114, 0.468 ± 0.126 and 0.353 ± 0.132 ppm, respectively. Statistical analytical results showed a significant elevation of lead contents in the examined samples especially in kareish cheese. Distribution of lead in some dairy products and their resultant by-products that are manufactured from manually contaminated milk by addition of 1.5 ppm lead acetate to the original milk was studied. The obtained results revealed that damietta and kareish cheese contained the highest lead levels, which reached about three to five times its level in other dairy products (cream, butter and yoghurt). Higher amounts of lead were released in the resultant butter milk, while other by products contained lower levels. Suggestive measures to protect human beings and animals from excessive intake of lead are given.

Key Word: Lead, Milk, Milk products.

INTRODUCTION

As early as 1968 International Dairy Federation (IDF) issued information on heavy metal contamination of milk and dairy products followed by further publications. Heavy metals make up one of the most important groups of pollutants in food supply (Protasowicki, 1992). As food-borne heavy metal intoxication is mostly limited to long-term consumption of food products from environments that contain high level of metals. The list of pollutants that are potentially hazardous to the human and animal life has increased rapidly in the last 40 years (Doyle and Spaulding, 1978).

Lead is considered one of the most hazardous pollutants to animal and human beings health status, as it is a threat to man via food and drink or inhalation. The presence of lead in the human food chain continues to be a major health problem world wide.

It is a cumulative poison that causes acute and chronic intoxication. Although acute poisoning is rare, chronic poisoning is more common and serious (Gossel and Bricker, 1990). Bioaccumulation of lead during chronic exposure and its mobilization and secretion with milk constitute a serious health hazard to the newly born children. The symptoms of acute poisoning in humans are well documented. Generally anorexia, dyspepsia and constipation are followed by an attack of colic with abdominal pain. Lead encephalopathy is also observed in young children. Lead toxicity is related to the levels of diffusable lead and lead content of soft tissue and occurs in three modes, the first is inhibition of haemoglobin synthesis, leading to anaemia, the second encephalopathia by toxic effects on nervous tissues with possible permanent function losses and third is invegetative system as while over 90% of the ingested lead goes into bony tissues (Carl, 1991). Also, lead potential carcinogenic nature has been reported by Zawurska and Medras (1988).

Kokori et al. (1998) stated that a case of an exclusively breast-fed 5-month old girl admitted to hospital after a generalized tonic - clonic seizure, followed by loss of consciousness for 20 min. The infant had been previously vomiting, constipated, lost weight and became pale and sluggish. It was subsequently found that the mother was using lead nipple shields.

The provisional weekly intake of lead in food must be not exceed than 0.05 mg/kg body weight as recommended by FAO/WHO (1989). However, Carl (1991) postulated that the acceptable limits ranged from 0.05-0.2 ppm.

As milk is an unique and essential for rapid growth and healthy development not only for the young but also for all ages, the present work was performed to determine the lead levels in milk and some milk products sold in Assiut City, as well as, to study the distribution of lead in some milk products and their corresponding by products manufactured from artificially lead contaminated milk.

MATERIAL and METHODS

A total of sixty representative samples of milk and some milk products including; cream, butter, kareish cheese, damietta cheese and yoghurt (10 samples of each) were randomly collected in clean containers from different markets in Assiut City during the year 2000, then transferred to the laboratory for estimation of lead.

Forty liters of raw milk were obtained from the dairy farm of the Faculty of Agriculture, Assiut University, then divided into four equal parts. Lead acetate was added to the first, second and third parts with a concentration of 1.5 mg/liter, while the fourth part was kept as control. Each part was used for manufacture of cream, butter, kareish and damietta cheese and yoghurt according to (Fahmy and Sharara, 1950; Harvey and Hill, 1967 and Lampert, 1975). Milk, milk products and their by products including the control samples were subjected for determination of lead levels.

Two grams from each sample was digested and estimated for lead by using Shimadzu Atomic Absorption Flame Emission Spectrophotometer AA-630-02, according to the method of Koirtyohann et al. (1982). The detection limit of the method adopted for lead was 0.01 mg/l.

Statistical analysis:

The obtained data were analyzed by using student's "t" test according to Snedecor and Cochran (1974). The obtained values in this study were compared with the Egyptian Organization for Standardization (1993) and the maximum acceptable limit of lead (0.2 ppm) reported by Carl (1991) from different countries.

RESULTS

The obtained results were recorded in Tables (1-3) and Figures (1 and 2).

DISCUSSION

As milk and milk products play an important part in man's diet and contribute greatly to the diet of the young, therefore, concern about the global pollution of the environment has led to many studies of the pathway of lead in milk.

Results presented in Table 1 and Figure 1 showed that the lead levels of the examined milk samples that randomly collected from Assiut City ranged from 0.01 to 1.13 ppm with a mean value of 0.324 ± 0.117 ppm. Lower lead levels were reported by Shehata and Saad (1992), who found that the mean lead levels were 0.019 ± 0.0 and 0.245 ± 0.016 ppm in cows and buffaloes milk collected from Assiut. While, our results are closely related to those reported by Tork (1994) and Fayed (1997) in Alexandria; El-Prince and Sharkawy (1999) in Assiut and Dabeka and Mckenzie (1995) in Canada. However, higher levels were estimated by Blood and Radostis (1989) and Muller et al. (1993).

The excretion of lead in milk was studied in cows after an episode of lead intoxication. A curvilinear relationship between lead in blood and milk was found (Murthy et al., 1967). In cattle, milk lead levels ranged from 0.028 to 0.030 ppm and may be elevated to as high as 2.26 ppm in severely poisoned cows (Blood and Radostis, 1989). In another study, its level in milk samples was < 0.020 to 0.130 ppm (Mitrovic et al., 1992), while, Muller et al. (1993) showed lead contents of 6.4 and 6.8 μg/L in farm and market milk. In India, Bhatia and Choudhi (1996) analyzed milk samples from cow, buffalo and goat for lead. Milk collected from the area of a heavy traffic contained 4.6 - 7.2 ppm. Thiemann et al. (1998) reported that the lead concentration in milk was elevated after an acute lead poisoning in a herd of dairy cows. Lead concentration in milk returned to the maximum level of 0.03 mg/liter by 42 days after poisoning.

The hygienic standards of the foreign substances contents in food stated that, 0.1 ppm is the maximum lead content in milk (Bartik and Piskac, 1981). The acceptable level of lead in milk was set in Britain at 0.04 mg per liter wet weight (Humphreys, 1991). Three samples out of ten examined milk samples (30%) exceeded the permissible acceptable limit of lead (0.2 ppm) reported by Carl (1991).

Concerning the examined milk products, cream samples contained lead values ranged from 0.02 - 0.86, with a mean value of 0.348 ± 0.080 ppm. While in butter samples, the lead levels ranged from 0.023 to 0.67

ppm with a mean value of 0.328 ± 0.048 ppm. It is also evident from Table (1) and Figure (1) that the lead levels in both kareish and damietta cheese ranged from 0.042 to 1.65 and 0.025 to 1.43 ppm with mean values of 0.859 ± 0.114 and 0.468 ± 0.126 ppm, respectively. However, the corresponding values in yoghurt samples ranged from 0.04 to 1.38 with a mean value of 0.353 ± 0.132 ppm.

Several previous studies indicated different levels of lead in milk products which sometimes lower or higher than our obtained results (Tahvonen and Kumpulainen, 1995; Zaky et al., 1995; Guidi et al., 1996 and Abdou and Korashy, 2001). Dabeka and Mckenzie (1995) estimated lead levels in 64 samples of milk and some milk products, and they found that its levels in the examined whole milk, skim milk, cream, yoghurt, cheese and butter were 2.3, 1.5, 1.9, 2.8, 14.6 and 16.4 ng/g, respectively.

Six samples (60%) of the examined kareish cheese exceeded the maximum permissible limits of lead in low fat cheese (0.1 mg/kg) which recommended by the Egyptian Organization for Standardization (1993). However, 2(20%), 2(20%), 4(40%), 3(30%), and 3(30%) of the examined cream, butter, kareish and damietta cheese and yoghurt samples exceeded the permissible acceptable limit of lead (0.2 ppm) reported by Carl (1991).

The present study revealed a highly significant elevation in lead content of the examined milk and milk product samples collected from Assiut City. This finding may be attributed to rearing of the dairy animals near roads and direct exposure to polluted air and water, also contamination may occur at several stages during processing. WHO (1977) stated that the major source of lead in the environment resulting from the manufacture and application of alkyl lead fuel additives.

To follow the fate of lead during manufacture of milk products, lead acetate was added to milk that is used to prepare samples of cream, butter, kareish cheese, damietta cheese and yoghurt. The results listed in Tables (2 & 3) and Figure (2) showed that the mean lead content of non contaminated milk was 0.309 ± 0.018 ppm which increased to 2.025 ± 0.172 ppm after addition of 1.5 ppm lead acetate.

Lead mean value was 0.258 ± 0.026 ppm in cream samples made from control milk, while it was elevated to 1.073 ± 0.249 ppm in samples made from lead contaminated milk. Corresponding values for skim milk samples obtained from such cream were 0.193 ± 0.048 and 2.16 ± 0.349 ppm, respectively. On the other hand, the mean lead levels in butter and their butter milk samples manufactured from control milk were 0.31 ± 0.061 and 0.223 ± 0.092 ppm, respectively, while in those made from contaminated milk the mean levels raised to 1.350 ± 0.192 and 3.140 ± 0.174 ppm. The mean levels of lead in both kareish and damietta cheese made from control milk were 0.446 ± 0.062 and 0.433 ± 0.084 ppm, respectively, while these values reached 6.250 ± 0.340 and 7.203 ± 0.420 ppm in such types of cheese obtained from contaminated milk. It is also evident from Table (2) and Figure (2) that the mean lead level in yoghurt made from control milk was 0.325 ± 0.056 ppm and 1.932 ± 0.351 ppm in yoghurt prepared from contaminated milk.

Our results revealed that, cheeses contained the highest level of lead. Similar results were reported by Marletta and Favretto (1983), who found that the concentration of lead in cheese produced from lead contaminated milk was about six times that in the original milk. The high lead levels in cheese samples compared with those of milk samples indicated that most of lead was bound to casein, while small amount was released in whey. The casein fraction in cow's milk contained 90-96% of the total amount of lead in the diet (Hallen and Oskarsson, 1995). The present results revealed a highly significant elevation of lead levels in milk products manufactured from contaminated milk, large amount of lead accumulated in some of these products, reaching about four times that of milk. Furthermore, high amounts of lead were released in buttermilk resulting from butter manufacture. These results emphasize the importance of warning about the hazardous effects of this pollutant on human being and newly born animals.

Studies involving the serial estimation of lead in milk and milk products especially cheese must be conducted regularly to avoid its hazardous effects. A certain measure of control over lead intake is exercised by the application of tolerance levels to selected foods.

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Table 1. Lead levels (ppm), number and percent above maximum limits (MLs) in milk and some milk product samples that randomly collected from different localities in Assiut City.

Samples	Lead levels (ppm)			No. & percent of samples above MLs (0.2 ppm)
	Min.	Max.	Mean ± SE	
Milk	0.010	1.13	0.324 ± 0.117**	3 - 30%
Cream	0.020	0.86	0.348 ± 0.080**	2 – 20%
Butter	0.023	0.67	0.328 ± 0.048**	2 – 20%
Kareish cheese	0.042	1.65	0.859 ± 0.114**	4 – 40%
Damietta cheese	0.025	1.43	0.468 ± 0.126**	3 – 30%
Yoghurt	0.040	1.38	0.353 ± 0.132**	3 - 30%

* Significant at $P < 0.05$ from the permissible acceptable limit (Carl, 1991).
** Highly significant at $P < 0.01$.

Table 2. Distribution of lead in some milk products that manufactured from milk contaminated with 1.5 mg/liter lead acetate.

Samples	Milk without addition	Milk with addition
	Mean ± SE	Mean ± SE
Raw milk	0.309±0.018**	2.025±0.172
Cream	0.258±0.026*	1.073±0.249
Butter	0.31±0.061**	1.350±0.192
Kareish cheese	0.446±0.062**	6.250±0.340
Damietta cheese	0.433±0.084**	7.203±0.420
Yoghurt	0.325±0.056**	1.932±0.351

* Significant at $P < 0.05$ from the permissible acceptable limit (Carl, 1991).
** Highly significant at $P < 0.01$.

Table 3. Distribution of lead in some milk by products that anufactured from milk contaminated with 1.5 ppm lead acetate.

Samples	Milk without addition	Milk with addition
	Mean ± SE	**Mean ± SE**
Skim milk	0.193±0.048*	2.16±0.349
Butter milk	0.223±0.092*	3.14±0.174
Whey Kareish cheese	0.263±0.052*	0.503±0.108
Whey Damietta cheese	0.353±0.041**	0.49±0.101

* Significant at $P < 0.05$.
** Highly significant at $P < 0.01$.

Figure 1. Lead levels in raw milk and some milk products collected from Assiut City

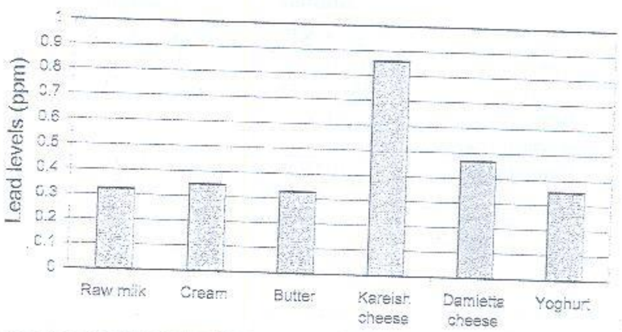

Figure 2. Lead levels in milk and prepared milk products before and after addition of lead acetate