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POLLUTION OF RAW AND PASTEURIZED MILK WITH SOME HEAVY METALS

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ABSTRACT

The present work was conducted to determine the levels of some heavy metals as cadmium, lead, copper and zinc in milk. A total of 100 samples of farm bulk milk (30), market raw milk (30) and pasteurized milk (40) were examined using Atomic Absorption Spectrophotometer. Results of chemical analysis of farm bulk milk revealed that the mean levels of the examined metals were 0.299 ± 0.016, 2.375 ± 0.013, 2.120 ± 0.030 and 5.750 ± 0.012 ppm., respectively. With regard to market raw milk the mean levels were 0.241 ± 0.037, 2.076 ± 0.163, 0.103 ± 0.006 and 3.844 ± 0.088 ppm., respectively. Concerning pasteurized milk, the mean levels were 0.17 ± 0.002, 4.53 ± 0.49, 1.69 ± 0.051 and 3.37 ± 0.012 ppm., respectively. According to the permissible limits of abroad the results indicated that 100%, 96.6% and 90% of farm bulk milk, market raw milk and pasteurized milk samples respectively contained cadmium, 100%, 100% and 95% respectively contained lead, 93.3, 93.3 and 95 respectively contained copper and 96.6, 93.3 and 98.3 respectively contained zinc beyond the maximum permissible limits for human consumption. The results of statistical analysis of examined heavy metals revealed that there is a significant difference between the farm bulk milk and market raw milk as well as market raw milk and pasteurized milk. The public health significance and suggested precautions for minimizing the levels of such metals were discussed.

INTRODUCTION

Environmental pollution with heavy metals led to a growing awareness of the potential hazards of heavy metal contamination in milk, water and feed stuffs which represent an important part of man and animal diet ***(Crossman, 1981)***. Heavy metals are among the chemical contaminants which have a major risk to animal and human health when present at higher concentrations but it known to be essential to human and animals life at low concentrations ***(Crosby, 1977).***

The toxic elements, which are considered of major interest in food safety include lead, cadmium and zinc. Zinc is recognized as nutrient and cadmium has no essential biological value but there are some suggestions that arsenic and lead might be nutritionally essential ***(Mahaffey, 1977).***

Contamination of milk starts at the farm and continue throughout the processing and distribution chain to storage and final preparation by the consumer or food service industry. So, good Manufacturing Practice (GMP) including processing, distribution and marketing are essential to ensure consumer protection ***(FAO, 1992).***

The toxic effects include central nervous system damage, permanent mental retardation in children, kidney diseases, acute gastroenteritis,acute pulmonary edema and possibly carcinogenesis***(Carl, 1991 and Skibniewska, 2002).*** The general adverse toxic effects are cumulative especially in adipose tissue. Other effects include off-flavours in food when present at high concentrations ***(Bluhean et al. 1984*** and ***Antoniou et al. 1989).***

In developing countries the problems regarding the unhealthy environment, bad sanitation and problems of poor environment have a negative and direct impact on the health.

Therefore, the present work aims to monitor the levels of some heavy metals in raw and pasteurized milk to ensure the availability of milk for consumption.

MATERIAL & METHODS

Collection of samples

A total of 100 samples of farm bulk milk (30), market raw milk (30) and pasteurized milk (40) were collected from Sharkia Governorate. The farm samples were collected weekly for 30 weeks from ten dairy cow's farm in capped polypropylene containers and preserved at-20 ºC till analysis. Market raw milk samples and pasteurized milk samples were collected from different shopping sites of the same Governorate to be analyzed chemically.

Analysis of heavy metals

The extraction of heavy metals from milk was carried out according to ***Hankinson(1975).*** In 250 ml capacity Erlenmeyer flask,equal volumes (50 ml each) of milk and tricholoroacetic acid (20%) were mixed by shaking frequently every 5 minutes for 30 minutes before being filtered through a 0.45 µn membrane filter, lead, cadmium, copper and zinc in filtered samples were quantitatively detected using Atomic Absorption Spectrophotometer.

RESULTS

Table (1): Levels of heavy metals (ppm) in farm bulk milk, market raw milk and pasteurized milk

Type of samples	Levels	Heavy metals			
		Cadmium	Lead	Copper	Zinc
Farm bulk milk	-Minimum	0.027	0.015	0.274	1.921
	-Maximum	0.539	3.827	5.983	11.869
	-Mean ± SE	0.299± 0.016	2.375± 0.0130	2.120± 0.030	5.750± 0.012
Market raw milk	-Minimum	0.058	0.850	0.025	2.400
	-Maximum	0.883	4.050	0.150	4.650
	-Mean ± SE	0.241± 0.037	2.076 ± 0.163	0.103± 0.006	3.844± 0.088
Pasteurized milk	-Minimum	0.03	1.76	0.65	0.11
	-Maximum	0.34	11.86	5.57	10.31
	-Mean ± SE	0.17± 0.002	4.53± 0.49	1.69± 0.051	3.37± 0.012

Table(2): Percentages of farm bulk milk, market raw milk and pasteurized milk samples beyond the maximum permissible limits.

Heavy metals	Permissible limits	Beyond the permissible limits						
		Limits (ppm)	Farm bulk milk		Market raw milk		Pasteurized milk	
	Country or organization		No/30	%	No/30	%	No/30	%
Cadmium	-Germany	-0.03	30	100	29	96.6	54	90
	-Netherlands	-0.05	30	100	29	96.6	54	90
	-Sweden	-0.02	30	100	29	96.6	54	90
	-Australian	-0.02	30	100	29	96.6	54	90
	-WHO (1980)	-0.02	30	100	29	96.6	54	90
Lead	-Germany	-0.005	30	100	30	100	58	95
	-Netherlands	-0.005	30	100	30	100	58	95
	-Sweden	-0.01	30	100	30	100	58	95
	-Australian	-0.05	30	100	30	100	58	95
	-WHO (1980)	-0.05	30	100	30	100	58	95
Copper	-Underwood (1977)	-0.3	28	93.3	28	93.3	57	95
	-Harison (1993)	-0.3	28	93.3	28	93.3	57	95
	-WHO (1980)	-0.3	28	93.3	28	93.3	57	95
Zinc	-Underwood (1977)	-3.0	29	96.6	28	93.3	59	98.3
	-Eos (1993)	-3.0	29	96.6	28	93.3	59	98.3
	-WHO (1980)	-3.0	29	96.6	28	93.3	59	98.3

Table(3): Correlation coefficient of some heavy metals farm bulk milk and market raw milk and market raw milk and pasteurized milk.

Metals	Farm bulk milk and market raw milk		Market raw milk and pasteurized milk	
Cadmium	a 0.128 ± 0.002	b 0.233± 0.0140	a 0.288± 0.014	b 0.187± 0.011
Lead	a 0.813± 0.031	b 2.272± 0.128	a 2.235 ± 0.125	b 2.390± 0.032
Copper	a 1.729± 0.016	b 2.119± 0.031	a 2.121 ± 0.032	b 2.133 ± 0.073
Zinc	a 4.229± 0.035	b 5.630 ± 0.011	a 4.998 ± 0.011	b 4.707± 0.82

a-b significant difference.

DISCUSSION

Contamination of milk by heavy metals is one of the major problems confronting public health. Cadmium, lead, copper and zinc receive greater attention than any other heavy metals due to their adverse toxic effects.

Therefore, it has become, important to determine the levels of toxic elements in milk as an essential part of human diet. The dairy animals expose to heavy metals from various sources as a result of modern industerialization. The levels of selected heavy metal concentration in farm bulk milk, market raw milk and pasteurized milk are represented in table (1). The mean levels of cadmium were 0.299 ± 0.016, 0.241 ± 0.037 and 0.17 ± 0.002 ppm respectively. More or less similar levels were obtained by Fayed (1997), Bayomi et al. (1999), Saad et al. (2001) and Karavoltsos et al., (2002). Lower levels were reported by Kirova (1993), Muller et al. (1993) and Enas and Sharkawy (1999).

According to the permissible limits recorded in different countries and organizations, results in table (2) reveal that 100%, 96.6% and 90% of farm bulk milk, market raw milk and pasteurized milk samples, respectively, contained cadmium above the maximum allowable limits. The sources of food contamination by cadmium were identified by WHO (1989) as phosphate fertilizers and sewage sludge used on agricultural lands, use of cadmium plated utensils and galvanized equipments in food processing and preparation, leachable cadmium in enamal and pottery and cadmium based pigments or sterilizes used food contact.

Cadmium is well recognized as one of the major toxic elements to man and animals. Even low levels may cause in time considerable accumulation in the tissues. It acts as sulfhyryl groups of essential metal enzymes. Higher concentrations are found in hat spots related to human activities and in agricultural lands where high concentrations of phosphate fertilizers and manure are applied ***(Scoullos et al., 2001)***. Cadmium toxicity may be manifested by a variety of syndromes and effects including renal dysfunction ***(Robards and Worsfold,1991 and Elinder and Jarup1996),***hypertension ***(Piperakia1985).***Moreover,it may induce prostate cancer, bone changes and slight anemia ***(WHO,1980).***

Lead is a non essential element for man, with a potential toxic for all biological systems, as it accumulates in human tissues. The mean values of lead concentrations found in farm milk, market raw milk and pasteurized milk samples were 2.375 ± 0.013, 2.076 ± 0.163 and 4.53 ± 0.49 respectively (Table 1). These findings are parallel to those obtained by ***Bayomi et al. (1990), Madeha et al. (1994) and Saad et al. (2001),*** lower levels were detected by ***Mitrovic et al. (1992) and Muller et al. (1993)***. High concentrations were recorded by ***Fayed (1997).***

Results showed in table (2) reveal that 100% of farm bulk milk, market raw milk samples and 95% of pasteurized milk samples contained lead beyond the maximum permissible limits. Similar results were recorded by ***Fayed (1997).***

Lead is considered one of the most important pollutants in the environment and is distributed widely in different of foods. The major sources of lead in the environment arises from the manufacture and application of alkyl lead fuel additives. Transport and distribution of lead from stationary or mobile source mainly via air. Although larger amounts are probably also discharged into soil and land tends to localize near the points of such discharge***(WHO,1977).*** Lead is an accumulative poison. It has hematological effects as it inhibits the hemoglobin synthesis ***(Carl, 1991).*** These effects may lead to anemia and microcythemia. High lead exposure causes encephalopathy resulting in ataxia, coma and convulsions ***(Ukhun et al., 1990).***

On the systems, long term exposures of lead reduces the function of completely damage kidneys, liver and brain tissues. Moreover, it causes constipation,diarrhea,epigastric pain, nusea and indigestion***(WHO,1977).***

It is obvious from the results present in table (1) that the mean copper concentrations of farm bulk milk, market raw milk and pasteurized milk were 2.120 ± 0.030, 0.103 ± 0.006 and 1.69 ± 0.051 ppm respectively.

The results also reveal that the copper levels decreased as the lead increases, these findings are substantiate to those reported by ***El-Hoshy et al. (1994) and Saad et al., (2001)***. It has been recorded that some toxic effects of cadmium were related to its copper depleting effects. Where decreasing in copper levels are associated with high cadmium concentration in human and animal organs and tissues ***(Lamphere et al. 1984).***

High levels of copper in raw, pasterurized and UHT milk were detected by ***Fayed et al. (1997).*** Normal copper level of copper in milk is 0.3 ppm as milk is a poor source of copper ***(Underwood, 1977).*** Results in table (2) indicate that 93%, 93% and 95% of farm bulk milk, market raw milk and pasteurized milk respectively, exceeded the tolerance limits for human consumption.

A copper is an essential trace element for human and animals, since it acts as a co-factor for several enzymes including cytochrome oxidase and tyrosinase maddition to its role in promoting hematopoiesis.

Copper is a very toxic at higher levels and causes many diseases such as Mediterranean anemia, liver cirrhosis and atrophy and hemochromatosis ***(Plavic and Casovic, 1988).*** Excess amounts of copper in food give rise to severe copper intoxication or copper poisoning known as Wilson's disease, because of its affinity for sulfhydryl group, but little is known about the maximum amount which may lead to toxicity. The low levels of copper increase the toxic effects of lead and increase its accumulation in system organs ***(Evans, 1971).***

Szajkowski (1996) pointed our that very low intake of copper was responsible for an inappropriate Zn:Cu ratio diet, even in the situation of Zn deficiency, which is approximately twice as high. Thus increasing the risk of cardiovascular diseases, abnormalities in bone mineralization and anemia in women.

Results present in table (1) reveal that the mean levels of zinc in farm bulk milk, market raw milk and pasteurized milk were 5.750 ± 0.012, 3.844 ± 0.088 and 3.37 ± 0.012 ppm respectively.

High levels were recorded by ***Fayed (1997).***

Zinc toxicity which results from inhalation of zinc fumes has been recorded to cause an illness called metal fumes fever ***(Kenneth, 1987).*** The normal zinc level in milk is 3 ppm. The results recorded in table (2) indicate that 96.6%, 93.3% and 98.3% of farm bulk milk, market raw milk and pasteurized milk samples respectively, exceeded the maximum tolerance limits for human consumption.

Fayed (1997) recorded that 100% of raw milk, pasteurized milk and UHT milk contained higher levels of zinc than the permissible limits. Zinc daily intake with the diets was adequate for women but insufficient for men ***(Skibniewska, 2002).***

Statistical analysis results recorded in table (3) point out there was a significant difference ($P > 0.05$) between farm bulk milk and market raw milk and between market raw milk and pasteurized milk regarding to analyzed heavy metals. This difference may be attributed to the different sources of milk, which depend on circumstance surrounding sources of contamination and dietary intake.

These results are coincident with those observed by ***Bayomi et al. (1999) and Saad et al. (2001).*** Contamination of animal feed by heavy metals has been considered the main source of metal residues in meat and milk ***(Jusklewiez, 1983)*** and the high levels of lead and cadmium in animal feeds resulted from plant origin due to application of fertilizers containing excessive amount of metals. The addition of considerable amount of processed cotton seed meal to such feeds ***(Mazurek et al., 1992 and Bayomi et al., 1999).***

Another explanation is the bioaccumulation of heavy metals in animal tissues and organs resulting in production of milk containing higher metal levels ***(Bluthgen et al., 1984 and Antoniou et al., 1989).***

In conclusion, the results of this investigation reveal that the examined milk samples proved to contain heavy metal beyond the permissible limits set by all organizations for human consumption, which may constitute a possible public health hazards. Therefore, monitoring of heavy metals in different types of milk in Sharkia Governorate should be done to deal with public health aspects and effects should be directed to minimize the heavy metals contamination of milk.

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تلوث اللبن الخام والمبستر ببعض المعادن الثقيلة

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معهد بحوث صحة الحيوان – الزقازيق

تعتبر العناصر الثقيلة من أهم الملوثات الكيميائية للألبان والتى لها آثار ضارة على صحة الإنسان والحيوان . لذا أجرى هذا البحث لتحديد مدى وجود بعض العناصر مثل الكادميوم والرصاص والنحاس والزنك فى ألبان المزارع (30 عينة) والألبان الخام المتداولة فى الأسواق (30 عينة) واللبن المبستر (40 عينة)

وقد أثبتت النتائج أن متوسط تركيز تلك العناصر فى ألبان المزارع كانت 0.299 ±0.016 ، 2.37 ± 0.13 و 2.12 ± 0.03 و 5.75 ± 0.012 جزء فى المليون على التوالى. بينما فى الألبان الخام المتداولة فى الأسواق كانت 0.241 ± 0.037، 2.076 ± 0.103،0.163 ± 0.006 ، 3.844 ± 0.088 جزء فى المليون على التوالى. وفى اللبن المبستر كانت 0.17± 0.002 ، 4.53 ± 0.49 ، 1.69 ± 0.051 ، 3.37 ± 0.012 جزء فى المليون على التوالى.

وقد أظهرت مقارنة عينات ألبان المزارع والألبان الخام النتداولة فى الأسواق واللبن المبستر بالحدود المسوح بها أن 100٪ ، 96.6٪ ، 95٪ كانت تحتوى على الكادميوم وأن 100٪ ،100٪ ، 95٪ كانت تحتوى على الرصاص وأن 93.3٪ ، 93.3٪ ، 95٪ كانت تحتوى على النحاس وأن 96.6٪ ، 93.3٪ ، 98.3٪ كانت تحتوى على الزنك على التوالى بكمية أعلى من الحدود المسموح

بها. وقد أوضحت نتائج التحليل الاحصائى للمعادن الثقيلة التى تم فحصها بأن هناك فرق معنوى بين ألبان المزارع والألبان الخام المتداولة فى الأسواق وكذلك الألبان الخام واللبن المبستر.

هذا وقد تم مناقشة النتائج وخطورة تلك المتبقيات على الصحة العامة وكذلك الاشتراطات الصحية الواجب مراعاتها فى إنتاج الألبان وتقليل نسبة تلك المتبقيات بها.