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Detection of Aluminum in Some Dairy Products at Kafr-El-Sheikh, Egypt

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Abstract: 155 samples of different dairy products (100 cheese; 40 milk powder; 10 full cream sweetened condensed milk and 5 full cream evaporated milk) were randomly collected from different supermarkets in Kafr-El-Sheikh Governorate, Egypt. Aluminum (Al) concentrations were detected using Nitrous oxide/Acetylene flame atomic absorption spectrometry after microwave digestion. Results revealed that the mean values of Al in examined dairy products ranged between 7.25 ± 1.43 – 57.58 ± 3.44 mg/kg. Al concentrations in some examined dairy products samples were low (3.60 – 46.60 mg/kg), while others showed higher concentration of this element (9.00- 94.00 mg/kg). The highest frequency distribution of examined cheese samples based on their Al concentration lied within the range of 40 -< 60 mg/kg, while for examined full cream milk powder samples was 56.7% and lied within the range of 3 -< 6 mg/kg. The highest frequency distribution of examined skimmed milk powder, condensed sweetened milk and evaporated unsweetened milk samples based on their Al concentration were 80, 90 and 100%, respectively and lied within the range of 9 -< 12 mg/kg. The determined Al concentrations in cheese in this study were higher than the limits of daily dietary intake estimated by FAO/WHO. Therefore, it was concluded that cheese are significant contributor to the intake of Al in Kafr-El-Sheikh, Egypt.

Key words: Aluminum · Cheese · Milk powder · Condensed milk · Evaporated milk · Atomic absorption spectrometry

INTRODUCTION

Aluminum (Al) is non essential element to humans, although it is one of the most common elements in our environment, comprising almost 8.8% of the earth's crust (88,000 ppm). Aluminum is not only the light silvery metal used to make pots, pans, airplanes; beverage cans and foil, but also has non metallic form which found everywhere. Aluminum compound is used in many diverse and important industrial applications such as alums (Aluminum sulfate) in water treatment and Alumina in abrasives and furnace lining. They are found in some consumer products such as antacids, astringents, buffered aspirin, food additives, antiperspirants, as emulsifying agent in many processed cheeses, especially those which are single-sliced and as anti-caking agent in dried milk. Aluminum occurs naturally in soil, water and air. It is redistributed or moved by natural and human activities. Level of Aluminum in the air generally ranges from 0.005 to 0.18μg/m^3. Most of Aluminum in the air is in the form of small suspended particles of dust [1].

Contamination of dairy products with Aluminum may result from the environment, but the concentration of this element increases notably with processing, packaging and food additives [2].

Minimal exposure to Aluminum isn't a problem; our bodies can excrete small amounts very efficiently, a tolerable daily intake (TDI) for Aluminum of 1mg/kg body weight/day has been established by an international committee of experts under the auspices of the world Health Organization (WHO) and Food and Agricultural Organization (FAO) of the United Nations [3]. Unfortunately, most of us are exposed to and ingest far more Aluminum than our bodies can handle also relative deficiency of Aluminum antagonists in the diets such as calcium and iron may increase the accumulation of this toxic mineral [4].

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There is a strong connection between Aluminum and Alzheimer's syndrome. Research clearly demonstrated abnormally high accumulations of Aluminum within the brains of Alzheimer's patient. Independent studies performed in Norway, the United Kingdom, France and Canada; showed a direct correlation between the prevalence of Alzheimer's syndrome and Aluminum concentration in drinking water. Besides Alzheimer's, toxic levels of Aluminum has also been associated with Parkinson's disease [5].Chronic Aluminum exposure has contributed directly to hepatic failure and dementia. Other symptoms that have been observed in individuals with high internal concentrations of Aluminum are colic, convulsions, esophagitis, gastroenteritis, kidney damage, liver dysfunction, loss of appetite, loss of balance, muscle pain, psychosis, shortness of breath, weakness, fatigue and birth defects in new born [1].

Due to all previous complications related to Aluminum consumption and there are, however no published records of Aluminum levels in dairy products in Kafr El-Sheikh Governorate, Egypt. This study was planned to determine the Aluminum contents in some dairy products using atomic absorption spectrometry after microwave digestion.

MATERIALS AND METHODS

Collection of Samples: 155 samples of different dairy products (15 Processed cheese; 10 Roquefort cheese; 10 Feta cheese; 15 Kareish cheese (Traditional soft cheese); 10 Damietta soft cheese; 10 Cheddar cheese; 10 Edam cheese; 10 Gouda cheese; 10 Ras cheese; 30 Full cream milk powder; 10 Skimmed milk powder; 10 Full cream sweetened condensed milk and 5 Full cream evaporated milk] were randomly collected from different supermarkets in Kafr-El- Sheikh Governorate, Egypt. All samples were analyzed before their expiry date. The collected samples were stored below -20°C prior to analysis.

Samples and Standards Preparation: Commercial standard solutions for atomic absorption spectrometry (AAS), BDH chemicals Ltd., Poole, UK, were used for Aluminum standard solutions. All reagents were of analytical reagent grade. Double-deionized water (18.2 MΩ cm.) was used for all dilutions. HNO_3 and H_2O_2 were of supra-pure quality (Merck, Darmstadt, Germany). The glasses used were thoroughly cleaned with water and detergent, rinsed with tap water followed by deionized water then with 10% v/v nitric acid and finally rinsed 4-5 times with deionized water. Teflon digestion vessels were rinsed with acetone, washed with deionized water, covered with 0.1 *M* HNO_3 for 30 min, rinsed with deionized water. Samples (2.0 g) were digested with 5 ml of HNO_3 (65%) and 2 ml of H_2O_2 (30%) in a microwave digestion system (Speed-wave four, Berghof, GmbH, Germany) for 31 min and diluted to 25 ml with deionized water. A blank digest was carried out in the same way (digestion conditions for microwave system were: 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min).

Analytical Parameters: A Perkin–Elmer AAnalyst 3110 model atomic absorption spectrometry with deuterium background corrector was used in this work. Al in samples was detected using Nitrous oxide/Acetylene flame and 0.1% potassium chloride as chemical modifier.

Statistical Analysis: The obtained results were statistically evaluated according to Rosner [6].

RESULTS

The results obtained for all dairy products having different composition are shown in Table 1. The data revealed that in some dairy products samples, the concentrations of Al were found to be in lower range (3.60 – 46.60 mg/kg), while others showed higher levels of this element, ranged as (9.00- 94.00 mg/kg). The mean values of Al in examined dairy products ranged as (7.25 ± 1.43 – 57.58 ± 3.44 mg/kg).

The highest frequency distribution of examined cheese samples based on their Al concentration lied within the range of 40 - < 60 mg/kg. One sample (6.7%) of processed cheese, 4 samples (26.7%) of Kareish cheese and 2 samples (20%) of Damietta cheese lied within the range of 60 - < 80 mg/kg. Only one sample (6.7%) of examined Kareish cheese lied within the range of 80 - < 100 mg/kg as displayed in Table 2.

The highest frequency distribution of examined full cream milk powder samples based on their Al concentration was 56.7% and lied within the range of 3 - < 6 mg/kg, while one sample (3.3%) lied within the range of 9 - < 12 mg/kg. The highest frequency distribution of examined skimmed milk powder; condensed sweetened milk and evaporated unsweetened milk samples based on their Al concentration were 80, 90 and 100%, respectively and lied within the range of 9 - < 12 mg/kg as shown in Table 3.

Table 1: Aluminum concentration in examined dairy products (mg/kg)

Dairy products	No. of examined samples	Concentration (ppm) Min	Max	Mean SE	S.E.M±
Processed cheese	15	39.00	60.00	47.01	2.10
Roquefort cheese	10	17.50	54.50	40.43	4.33
Feta cheese	10	38.60	56.90	51.66	2.25
Kareish cheese	15	41.30	94.00	57.58	3.44
Damietta soft cheese	10	42.00	69.30	54.04	2.97
Cheddar cheese	10	37.00	53.40	45.00	1.92
Edam cheese	10	37.10	59.10	51.09	2.44
Gouda cheese	10	36.90	57.60	44.59	2.45
Ras cheese	10	46.60	55.60	52.06	1.03
Full cream milk powder	30	3.60	9.00	7.25	1.43
Skimmed milk powder	10	8.80	10.70	9.90	0.25
Full cream sweetened condensed milk	10	8.90	11.00	10.06	0.22
Full cream evaporated milk	5	10.40	10.70	10.54	0.05

Table 2: Frequency distribution of examined cheese samples based on their Aluminum concentration

	Processed cheese		Roquefort cheese		Feta cheese		Kareish cheese		Damietta soft cheese		Cheddar cheese		Edam cheese		Gouda cheese		Ras cheese	
Frequency	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
<20	0	0.0	2	20	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0
20 -<40	2	13.3	2	20	2	20	0	0.0	0	0	2	20	2	20	4	40	0	0
40 -<60	12	80.0	6	60	8	80	10	66.6	8	80	8	80	8	80	6	60	10	100
60 -<80	1	6.7	0	0	0	0	4	26.7	2	20	0	0	0	0	0	0	0	0
80 -<100	0	0.0	0	0	0	0	1	6.7	0	0	0	0	0	0	0	0	0	0
Total	15	100.0	10	100	10	100	15	100.0	10	100	10	100	10	100	10	100	10	100

Table 3: Frequency distribution of examined milk powder and concentrated milk samples based on their Aluminum concentration

	Full cream milk powder		Skimmed milk powder		Condensed sweetened milk		Evaporated milk	
Frequency	No	%	No	%	No	%	No	%
1 -<3	0	0.0	0	0	0	0	0	0
3 -<6	17	56.7	0	0	0	0	0	0
6 -<9	12	40.0	2	20	1	10	0	0
9 -<12	1	3.3	8	80	9	90	5	100
Total	30	100.0	10	100	10	100	5	100

DISCUSSION

Aluminum has been the focus of much negative attention lately; numerous studies have indicated that Al accumulates in the body, especially in nerve tissues, potentially causing harm [1]. The present study focused on assaying the concentration of Al in different dairy products. Results revealed that the highest (94.00 mg/kg) and the lowest (3.60 mg/kg) Al amounts were determined in Kareish cheese and full cream milk powder samples, respectively. Kareish cheese is mostly a home-produced cheese type and its production is not controlled. Large amounts of Al contamination result from the uncontrolled use of low quality materials made from Al used for storage of this type of cheese, also the acidity of cheese can give rise to corrosion of Al in pots and increases the rate of contamination with Al. The low Al content in full cream milk powder could be attributed to its technological production conditions and the use of non-Al-containing materials in the process.

In the present study, contrary to what has been expected that the processed cheese contained Al more than other types of cheese due to presence of emulsifier (sodium aluminum phosphate), Kareish cheese, Damietta cheese and Ras cheese appear to have Al concentrations (57.58, 54.04 and 52.06 mg/kg) more than processed cheese (47.01 mg/kg), this may be attributed to uncontrolled production of these types of cheese in

Egypt and perhaps to environmental contamination. At any rate, all examined cheese samples were found to contain high amount of Al and probably arise from the food additives or other ingredients.

Milk powder, full cream sweetened condensed milk and full cream evaporated milk were found in this study to contain low Al concentration, this may be attributed to production of these products under controlled conditions and additives used in full cream sweetened condensed milk production such as sugar are also effective in reducing Al contents [7]. The great variability found in the Al contents in different dairy products, suggests that contamination occurs during the manufacturing or storage processes.

Ranau *et al.* [8] reported that Al migration depends on several factors as the chemical composition of food material and other ingredients, the conditions of preparation (duration and temperature of heating), the pH-value of food and the presence of any other substances (such as organic acids and salts), which complicate the reactions, result in dissolution of the complex Aluminum.

The Al has historically been considered to be relatively non-toxic in healthy individuals, who can tolerate oral daily doses of 1 mg/kg of body weight per day of Al without any apparent harmful effects [3]. Moreover, high intakes of Al by susceptible individuals (especially, those with impaired kidney function including the elderly and low-birth-weight infants) may lead to pathological changes [9, 10]. Children are more sensitive to toxic effects of Al because there are significant differences in absorption, distribution, metabolism and excretion of this element between children and adults [11].

According to the notifications in the Turkish Food Codex (TFC) and European Communities regarding the determination of the maximum levels of contaminants in food products, Al amount should not exceed 15mg/kg [12]. According to several authors, the Al dietary intake must not exceed 6 mg/day to avoid potentially toxic levels [13]. Pennington and Schoen [9] estimated dietary Al intake in USA as 0.7–11.5 mg/day in children, 8–9 mg/day in men and 7 mg/day in women. Ysart *et al.* [14] estimated the mean dietary Al intake in the United Kingdom as 3.4 mg/day. The Joint FAO/WHO Expert Committee on Food Additives [15] provisionally estimated a tolerable weekly intake of 7.0 mg/kg body weight and noted that dietary intake normally ranged from 2 to 6 mg per day in children and from 6 to 14 mg/day in adults. A tolerable daily intake (TDI) for Al of 1 mg/kg of body weight per day has been established by an international committee of experts under the auspices of the World Health Organization (WHO) and the Food and Agricultural Organization (FAO) of the United Nations [3].

According to HC [16] and USDA [17] the amount of milk group that are recommended each day 2-4 (for children and teens) and 2-3 cups (for adults), the cup is equal to 50-60 g cheese; 250 ml reconstituted milk powder and125 ml canned milk. The examined cheese samples contribute about 8-11.6 mg per day of Al to the daily dietary intake. Biego *et al.* [18] indicated that the principal source of Al daily intake is milk and dairy products (36%).

In conclusion, Aluminum contents in cheese determined in this study were higher than the limits of daily dietary intake estimated by FAO/WHO. Therefore, cheese could be considered as significant contributor to the intake of Aluminum in Kafr-El-Sheikh, Egypt. Increased awareness and controlled manufacture of these products are necessary in order to decrease the contents of Aluminum.

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