Original article

Estimation of Aluminum (Al) Leaching from Aluminum Utensils in Libyan Food

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Abstract

Cooking in aluminum utensils often causes relatively small increases in Aluminum (Al) content of food. In Libya, data on Al concentration in food items are scarce, although aluminum vessels are widely used to cook foods, and it is known that Al can migrate from cooking utensils to food. This study was carried out to evaluate the leaching content of Al from new and used (old) aluminum cookware to four common Libyan food groups (vegetables, beans, cereals and meats). We evaluated the concentration of Al in a total of 45 samples of different food items that are widely consumed in Libyan diet. Al was determined using Agilent's 240 AA Atomic Absorption Spectrometer integrated GTA 120 Graphite Tube. The Al concentration in foods was reported in terms of ppm dry weight of the foods. The concentration of Al in leafy vegetables, pulses, potatoes, cereals meats, cooked in new aluminum cookware were 12.78, 10, 1.9, 0.9 and 0.85 ppm. Al concentration in the used cookware was 11, 5.34, 1.51, 0.68 and 0.19 ppm, while these values of Al levels for foods cooked in stainless steel cookware were 8.05, 3.11, 1.14, 0.37 and 0.16 ppm of food tested samples respectively. The Al content of foods cooked in new Al was higher than that cooked in old Al or stainless steel vessels. More attention should be paid to Al concentration in foods in order to minimize dietary intake and to protect our health.

Keywords: Aluminum cooking utensils, Foods, Health hazards

Introduction

Aluminum (Al) is the third most abundant element in the earth's crust and is therefore a natural component of drinking water and foodstuffs and is a component of many manufactured materials. Exposure of the human body to Al may be via food including drinking water; fruit juices vegetables, meats and beans (Stahl *et al.* 2011).

Under acidic conditions, Al is solubilized increasing availability to plants and aquatic animals (Ritchie 1995). Soil acidification due to application of fertilizers, growing of legumes, or acid rain is an increasing problem in agricultural and natural ecosystems (Marschner 1995). Increased Al exposure can be compensated for by excretion via intestines and normal, healthy kidneys (Ganrot 1986).

Al is found as visible in pots and pans, invisible in food, water and air. The general population is principally exposed to Al from intake of food and water, particularly foods containing Al compounds used as food additives. Al is absorbed and may accumulate in different organs in both infants and adults (Soni *et al.* 2001).

Al has a hazardous effect upon health, it was linked to many health risks mainly Alzheimer's disease which is the commonest form of dementia. Two groups seem to be at particular risk for Al related toxicity: people with chronic renal failure treated with Al-containing medications and pre-term infants fed on Al containing formulate (Lidsky 2014).

Foods containing the highest amount of Al are spices, herbs and tea leaves. However, these food products contribute only a small amount to the total amount of Al consumed per day due to the fact that spices are used in such small amounts and that much of the Al in tea does not dissolve into tea infusions when this beverage is prepared. The highest source of Al in Libyan diet is food additives (e.g., Al salts added to processed cheeses, candies and pickles such as Al chloride, Al nitrate and Al sulphate).When the foods are cooked or stored in Al containers some amounts of the Al may migrated into foods and water. This often results in a relatively small increase in Al content of food (Soni *et al*. 2001).

Al-induced neurotoxicity is well known and it is, may be a factor in the etiology of various toxicity and neurodegenerative disorders in man (Thomas *et al.* 2015). The various health effects of Al had separated into three categories: neurological disorders (other than cognitive decline or AD); cognitive decline; and dementia or Alzheimer's disease (Rondeau 2002).

This study aims to examine the levels of Al concentration in some common Libyan dishes and selected (uncooked and cooked) food items available in the markets in Tripoli to know the potential dietary exposure to Al of the population in Libya.

Materials and Methods

A total of 45 samples of popular Libyan foods were collected from different local markets in Tripoli. The food samples including representing a typical Libyan dishes (Harisa, macaroni, CusCous , Rushda, Bazine and Tomato sauce). Uncoated Al (old Al and new Al), and stainless steel saucepan whose inner diameter and depth were 16.0 and 10.5 cm, respectively were used for cooking of the collected for samples. The saucepans were cleaned with a detergent and rinsed well with distilled water before use. All the foods tested contained

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small amounts of Al naturally. However, the actual amounts of Al that were added to foods through the use of cooking utensils were estimated. Al concentration was estimated in part per million (ppm) of dry weight. The sample was homogenized and digested sequentially with concentrated nitric acid and sulfuric acid.

The concentration of Al content was determined in Triplicates in uncooked and cooked samples. The sample was homogenized and digested sequentially with concentrated nitric acid and sulfuric acid.

Sample preparation

Food samples were dried for 24 h at 80^o C and grinded in a mill with No 20 stainless steel sieve and store in air tight container in dry atm. Into a macro Kjeldahl digestion flask preferable made of silica, place 10 gm, 20 ml conc nitric acid and up to 20 ml of distilled water. Boil so that the volume is reducing to about 20 ml, cool and add 10 ml of concentrated sulphuric acid. Boil again and add further small quantities of nitric acid immediately the liquid begins to blacken. When the addition of nitric acid is no longer necessary (i.e. when the liquid no longer blackens), continue the heating until white fumes are well in evidence. Cool and add 10 ml of saturated ammonium oxalate solution and boil again copious white fumes are again produced, so that the final solution is colorless. Every trace of nitric acid must be removed before proceeding. A blank was prepared at the same time (Sidney 1984).

The Al level was determination by using Agilent's 240 AA Atomic Absorption Spectrometer integrated GTA 120 Graphite Tube in the laboratories of Food and Drug Control Center (FDCC), Tripoli. All glassware was washed, soaked in 1% nitric acid and rinsed with demineralized distilled water. The accuracy and precision of the proposed method was expressed as relative standard deviation, ranged from 0.0 to 15 %. Analytical characteristics under the selected conditions, the standard calibration of Al in the range of 5-10-15and 20 ppm were constructed by plotting of absorbance versus concentration of Al.

Results and Discussion

The aluminum cooking utensils are the most commonly used cookware in some cities of Libya, this study was undertaken to evaluate the contribution of aluminum cooking utensils to the daily intake of Al. 45 commonly consumed food items were selected from Tripoli markets and analyzed for their Al content. There is an extensive data available from the literatures of WHO and Europe, regarding the toxicity of Al to the health, while it is scanty from Libya and African countries. However, Herbs, spices and tea have a naturally high content of Al reached in our study up to 61.20 ppm. Cooking foods in aluminum utensils have a significant increase in Al content of cooked foods.

Results obtained revealed that the different food items studied recorded variable levels of Al (Table 1).

Table 1. Comparison of Aluminum (Al) levels in tested samples of foods in current study and those in previous literatures. Mean (relative standard deviation RSD %) (ppm)

Food items	Current study	Previous literature (Greger 1992)	Food items	Current study	Previous literature (Greger 1992)
Spices and herbs	61.2 (1.12 %)	8.2 - 75.0	Roots	18 (0.16%)	0.374 (Lopez *et al.* 2000)
Cardamom	12.3 (3.49%)	2.30-20.00	Radish root	18.0 (0.16%)	18.0
Coriander	3.41 (0.08%)	2.70-3.60	Turnips	0.22 (0.01%)	<0.1
Cumin	40 (1%)	27.3-57.00	Potatoes	2. 0 (0.1%)	2.00
Garlic	0.7 (1%)	*0.5-.1.0*	Cereals	0.11 (0.01) (9%)	
Pepper black	5.0 (1%)	48-273	Barley	2.10	0.50-0.67
Turmeric	55.0(5.52) (10%)	50.0-64.0	Wheat flour	1.30 (0.1%)	<1.0
Thyme	71.3(1.12) (1.57%)	50.0-100.0	Bread (whole wheat)	0.75 (5.33%)	0.54 (Greger 1985).
Harisa*	0.47 (0.014%)	--	Bread, white	1.00(0.01) (10%)	0.30
Vegetables	0.50 (1%)	0.01 - 0.44	Macaroni uncooked	0.70 (7.14%)	< 0.20
Cucumber	0.12 (0)	0.40	Rice uncooked	1.0 (0.1%)	0.01-0.44 (Sternweis and Gilman 1982)
Parsley	0.60 (2.8%)	4.50	Cheese cottage	0.18 (3.7%)	<25.7
Spinach	1.47 (2.7%)	2.52 (Greger 1985).	Cheese, processed	32.0 (6.2%)	29.7
Cabbage	0.26 (6.53%)	<0.1	Lentils	0.25 (8.0%)	0.15
Celery leaves	3.10 (1.26%)	<1.00	Peas	1.05 (7.76%)	3.60
Lettuce	1.20 (2.16%)	0.55	Tea bag, dry	118.10 (10.25%)	128 (Greger 1985).
Meat lean beef	0.20 (15%)	0.02 - 0.12			

*Harisa is pepper sauce contains garlic and salt. Commonly used by Libyans in sandwiches and some dishes

These values of Al concentration in the foods tested in our study were compared with those reported in more recent literatures. The concentration of Al in leafy vegetables, pulses, potatoes, cereals meats, cooked in new aluminum cookware were 12.78 ppm, 10, 1.9, 0.9 and 0.85 and for the used cook wares 11, 5.34, 1.51, 0.68 and 0.19 (ppm. dry weight), while these values of Al levels for foods cooked in stainless steel cookware were 8.05, 3.11, 1.14, 0.37 and 0.16 ppm of food tested samples respectively (Table 2).

Table 2. Estimated Aluminum (Al) content of tested samples of food after cooking in old and new aluminum or stainless steel cookware. Mean and (relative standard deviation RSD%) (ppm)

Food items	Cooking for 30 minutes		Cooking for 90 minutes in stainless steel
	Old aluminum	New aluminum.	
Vegetables	1.50 (6.6%)	1.93 (5.18%)	1.20. (8.3%)
Leafy vegetables	11.0 (6.9%)	12.78 (1.56%)	8.05 (0.17)
Pulses(beans, chickpeas, lentils)	5.34 (6.7%)	10.0 (5.0%)	3.11 (4.18%)
Roots (turnips, carrots, radish)	5.02 (0.13%)	5.22 (5.36%)	1.55(3.22%)
Potatoes	1.50 (6.6%))	1.90 (5.26%)	1.14(8.77%)
Cereals (macaroni ,CusCous , Rushda and Bazine, Rushda)	0.68 (0.02%)	0.90 (11.1 %)	0.37(4.05%)
Meats , lean beef	0.19 (5.2%)	0.85 (5.8%)	0.16 (9.37%)
Tomato sauce	4.80 (5.41%)	6.71 (4.3%)	3.41(5.27%)

Foods containing the highest amount of Al are spices, herbs and dried tea leaves. However, these food products contribute only a small amount to the total amount of Al consumed per day due to the fact that spices are used in such small amounts and that much of the Al in tea does not dissolve into tea infusions when this beverage is prepared. The Al content of black tea is ranging from 0.30 to 0.99 mg Al/bag, while in Green tea was 0.024-0.32mg|bag (Sternweis and Gilman 1982).

Al can dissolved and accumulate in foods stored or cooked in uncoated Al pans. The concentration of Al that accumulates in foods during preparation depends on the pH of the foods, the length of cooking periods and the types of utensils. Acid foods, particularly tomato products can accumulate more amounts of Al during the cooking period.

The longer cooking time in aluminum utensils, the greater the accumulation of Al in food.

Indeed all the tests in our study appear to have comparable Al concentrations to foods locally consumed in countries such as Europe countries and USA (Table 3). We can conclude that food pollution with Al may, to some extent, be augmented by using of the Al cutlery and kitchen utensils. Method of food preparation determines the extent of Al leaching from the vessels. It appears that the daily intake of Al in certain populations where aluminum utensils are regularly used could be much higher when compared to those who use stainless steel cookware. New Al vessels contribute greater amounts of Al especially when green leafy as well as other vegetables and legume preparations are cooked in them.

Table 3. Aluminum (Al) concentration estimated in some cooked foods, in comparison with reported Al content from literatures. (ppm)

Food	Uncooked		Cooked in Al		Cooked in stainless steel	
	Current study	Previous reports (ATSDR 2008)	Current study	Previous literature	Current study	Previous literature (ATSDR 2008)
Beans	0.52 (11.5%)		7.95 (5.4%)	3.47		2.82
Potatoes	18 (0.16%)	2.00	2.50 (8.0%)	0.64	1.04 (4.8%)	0.37
		2.45		4.27		27.39
Tomato sauce	0.15 (6.6%)	1.00- 1.5	6.71 (4.17%)	3.87	2.8 (6.07%)	3.17
Meats , lean beef	0.44 (6.8%)		0.85 (5.88%)	-	0.62 (11.6%)	(0.02 - 0.12)

*Common Libyan dishes (Cuscous prepared from semolina, while Bazine from Barley flour and Rushda is prepared from wheat flour)

Al is consumed mainly through cereals, cheese and salt, while herbs, spices and tea have a naturally high content of Al (Mohammad *et al.* 2011). The study revealed that the major contribution of Al from Libyan foods is through consumption of vegetables, spices and pulses cooked in Al vessels. Cereals, contribute negligible amounts. Usage of aluminum utensils contribute significantly to the total daily Al intake specially when preparing green leafy vegetables and tea (popular beverage). It should be emphasized that the foods tested in our study are only selected samples of foods and local dishes (Couscous, Bazine , Rushda) which are popular meals for Libyan people. In addition to traditional foods were included such as tea, spices and herbs. However, more studies are needed to calculate the average daily Al intake for Libyans.

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