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Contamination of Aluminium from Cooking Utensils and Yogurt Containers

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The neurotoxicity of aluminum has been known for more than a century (Zatta 2000). More recently, it has been implicated as an etiological factor in some pathologies such as encephalopathy, bone disease and anemia related to dialysis treatment. In addition, it has been hypothesized to be a cofactor in the etiopathogenesis of some neurodegenerative diseases, including Alzheimer's disease (Nicolini et.al. 1994). Furthermore, an increased concentration of Al in infant formulas and in solutions for home parenteral nutrition has been associated with neurological consequences and metabolic bone disease, characterized by low-bone formation rate, respectively (Zatta et. al. 1997). The main sources of aluminium for the human organism are foods and drinking water as well as dialysis fluids for people undergoing renal treatment. For all these reasons, it is recommended that the aluminium content should be declared in all food preparations and pharmacological products. On the other hand, the maximum permissible aluminium in drinking water is withdraw down from 200 $\mu g\ L^{-1}$ (Mohammad et. al. 1992) to 50 $\mu g\ L^{-1}$ (Zatta 2000). In addition, measurement of aluminium must be undertaken with great care. The Joint Food and Agricultural Organisation (FAO)-World Health Organisation (WHO) Expert Committee on Food Additives established the provisional tolerable weekly intakes for adults of 7.0 mg Al kg^{-1} (WHO 1989). Total and different species of Aluminium in the tea and drinking water samples have been studied among the food and beverage samples (Nabrzyski and Gajewska 1998; Erdemoglu et. al. 2000; Pyrzynska et. al. 2000; Yaman 1998). Apart from these samples, cooking utensils may be a very important source of high aluminium in meal. Published reports on aluminium concentration in food and beverage samples include results electrothermal atomic absorption spectrometry (ETA-AAS), inductively coupled plasma atomic emission spectrometry (ICP-AES), and neutron activation analysis (NAA) and others. However, the high chloride contents that are found in most matrices cause volatilisation losses because of volatile nature of $AlCl_3$ occurred and some other ions such as PO_4^{-3}, SO_4^{-2}, Ca^{+2} interfere during the electrothermal Al determination (Massey and Taylor 1991). Neutron activation analysis (NAA) is very sensitive but suffers from difficulties associated with the masking of the Al peak by sodium and chloride species during counting, the conversion of P and Si into ^{28}Al and the short half-life of ^{28}Al. In the determination of Al by ICP-AES,

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samples containing high concentration of Ca can cause serious spectral interference and a good background correction system is necessary to overcome this interference. Flame atomic absorption spectrometry (FAAS) was also employed for the determination of Al at low concentrations by combining with suitable enrichment steps (Nabrzyski and Gajewska 1998; Yaman 1998).

In this study, aluminium concentrations in Turkish meals cooked in new and old aluminium and the various other cooking utensils were determined by flame atomic absorption spectrometry (FAAS). In addition, Al amounts leached from yogurt fermented in various containers made from new and old aluminium, steel and boron glass were determined at the soured and fresh (non-soured) conditions. On the basis of our experience related with accuracy and reliability of the metal determinations in various matrices (Yaman et. al. 2000; Yaman 2000a; Yaman 2000b; Yaman and Gucer 1994; Yaman and Gucer 1995a; Yaman and Gucer 1995b; Yaman 1997; Yaman and Gucer 1998; Yaman 1999; Yaman 2001; Gucer and Yaman 1992), the reliable results were obtained in this work.

MATERIALS AND METHODS

An ATI UNICAM 929 Model atomic absorption spectrophotometer (AAS) equipped with ATI UNICAM Hollow cathode lamp was used for Al determination. The optimum conditions for AAS are follow: wavelength of 309.3 nm, HCL current of 9.5 mA, acetylene flow rate of 4.2 L min^{-1}, N_2O flow rate of 4.7 L min^{-1} slit width of 0.5 nm.

Unless stated otherwise, all chemicals used were of analytical-reagent grade. Throughout all analytical work, double distilled water was used. All glass apparatus have been kept permanently full of 1 mol L^{-1} nitric acid when not in use. In the digestion procedure, platinum dishs, concentrated nitric acid (65%, Merck) and hydrogen peroxide (35%, Merck) were used. Stock solution of Al (1000 mg l^{-1}) was prepared by dissolving aluminium metal in minimum nitric acid and diluted to suitable volume by 1 mol L^{-1} HNO_3.

The studied meals were prepared as follow by using cooking utensils made from different materials such as new and old aluminium, steel, clay, aluminium folio,Teflon, boron glass and tinned copper.

For meal 1, The mixture of 110 g tomato+35 g pepper+30 gr onion+5 g salt+ 30 gr vegetable oil+one egg were cooked for 20 min on the cookstove.

For meal 2, The mixture of 110 g tomato+35 g pepper+30 gr onion+5 g salt+ 30 gr vegetable oil+ 15 g meat+ 10 g tomato sauce were cooked for 40 min on the cookstove.

The cooked meals were transferred to the beakers and dried at 90 °C, for 24 h. The weighed dried meals were placed in a platinum dish and ashed at 500 °C for 8 h. This process was repeated, if necessary, until a white ash was obtained. Minimum

volumes of the mixture of nitric acid-hydrogen peroxide (1/1) were added to the ashed samples and dried with occasionally stirring on a hot plate with low heat. After dried, 1.5 mL of 1.0 mol L^{-1} HNO_3 was added to each samples and centrifuged. The clear solutions were analysed by FAAS. A blank digest was carried out in the same way.

Yogurt samples were fermented in the containers made from new and old aluminium, steel and boron glass materials. 2.0 g of yogurt sample were transferred to a platinum dish and dried in an oven at 95 °C for 10 h. The dried sample was ashed at 500 °C for 4 h. Minimum volume of the mixture of nitric acid-hydrogen peroxide (1/1) were added to the ashed sample and dried with occasionally stirring on a hot plate with low heat. After dried, 1.5 mL of 1.0 mol L^{-1} HNO_3 was added and centrifuged. The clear solution was analysed by FAAS. A blank digest was carried out in the same way. A second part of the same yogurt sample were soured in the same containers described above for fresh yogurt. Then, 2 g of these soured yogurt were digested by using the same procedure described above for fresh yogurt.

RESULTS AND DISCUSSION

Calibration graph was obtained by using Al solutions in range of 1.0-50.0 mgL^{-1}. The equation of the calibration curve was as follow:

$$Y= 5.2X + 0.1 \qquad R^2=0.99$$

The levels of Al in reagent blanks were 0.3 mg L^{-1} with standard deviations of 0.08. The limit of detection, defined as three times the standard deviations of the blank were, therefore, 0.24 mg L^{-1}. To assess the accuracy of the total procedure in the presence of meal and yogurt, recoveries of Al from these samples fortified with this element were found. The spiked aluminium to the samples is 1.0 mg kg^{-1} for meal and yogurt. It was found that at least 90 % of Al added to these samples were recovered. The effect of contamination was eliminated by subtracting values obtained for blanks.

The found aluminium concentrations for Turkish meals by using the cooking utensils made from different materials were given on Table 1. As seen from this Table, Al concentrations in the meal 1 by using steel, Teflon, boron glass and tinned copper were very close to each other. Thus, it can be said that these concentrations are only from the meal. On the other hand, Al concentrations in the meal 1 obtained by using the aluminium folio container were slightly higher than the described above utensils, but these increased levels are not important. Al concentrations in the meal 1 cooked in new Al and clay utensils were higher than the described above utensils and these concentrations concerning with these two utensils are close to each other. Al level in the meal 1 cooked in old Al utensil is approximately three-fold higher than the other utensils.

As seen from Table 1, Al concentrations in meal 2 cooked in Al folio, steel, Teflon, boron glass and tinned copper were very close to each other. Hovewer, these values are higher than the values obtained from the meal 1 by using the

same utensils for cooking. As similar described above, it can be said that these concentrations are only caused from the meal 2, not leached from utensils. On the contrary to meal 1, Al concentrations in the meal 2 cooked in clay and new Al container are different from each other. The Al concentrations of meal 2 cooked in new Al utensil are very higher than the clay utensil. Al level in the meal 2 cooked in old Al utensil is almost three-fold higher than the new Al utensil. In addition, Al concentrations in the meal 2 cooked in old Al utensil are completely two-fold higher than the meal 1 by using the same utensil.

As a result, an increase in Al level was found for meal 2 cooked in new Al utensil in comparing to other utensils except old Al, However, the increase in Al level of the same meal cooked in old Al utensil was significantly higher than that of the new aluminium. We consider that all these increases are due to high acid.tomato sauce

It is seen from Table 2 that Al concentrations of yogurt samples fermented in both steel and boron glass are equal to each other in both soured and non-soured conditions. Aluminium level in the fresh yogurt fermented in new Al container are twenty six-fold higher than that of steel and boron glass containers. The values obtained in the case of soured yogurt are two times higher than that of the fresh yogurt, in the new aluminium container. The Al concentration of the fresh yogurt fermented in the old Al container is close to that of the soured yogurt in new Al container. Al concentration in the soured yogurt in old Al container is excessively higher and dangerous for health.

According to the limitation of 1.0 mg Al kg^{-1}, daily, suggested by The Joint Food and Agricultural Organisation (FAO)-World Health Organisation (WHO) Expert Committee on Food Additives (WHO 1989), in one day, the eating more than 38 g of the yogurt soured in the old Al container is overcome this limitation. On the other hand, in one day, the eating more than 532 g of the fresh yogurt fermented in the old Al container or the yogurt soured in the new aluminium container is still overcome this limitation. In the literature, Al levels in yogurt samples were given in range of 0.11-4.38 (average 1.28) mg/kg (Bjorksten 1988). Therefore, we suggest that Al containers should not be used for fermentation and for storage of yogurt. In addition, Al utensils should not be used for cooking of meals based acid.

Table 1. Al concentrations of meals cooked in the utensils made from different materials.

Cooking Utensil	Al in meal 1 mg/kg (dried weight)	Al in meal 2 mg/kg (dried weight)
Old Al	11.0±1.0	22±1.9
New Al	3.5±0.2	8.0±0.5
Clay	4.0±0.3	5.0±0.4
Al folio	2.5±0.2	3.5±0.2
Steel	2.0±0.1	3.5±0.2
Teflon	2.0±0.1	4.0±0.2
Boron glass	1.6±0.1	3.3±0.2
Tinned Cu	1.5±0.1	3.5±0.2

n=5

Table 2. Al concentrations of yogurt fermented in the containers made from different materials at the soured and fresh (no soured) conditions.

Containers	Al in yogurt- No soured mg/kg (fresh weight)	Al in yogurt-soured mg/kg (fresh weight)
Old Al	150±12	2100±60
New Al	65±4	150±6
Steel	2.5±0.1	2.5±0.1
Boron glass	2.5±0.1	2.5±0.1

n=5

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