ALUMINUM MIGRATION INTO SOME EGYPTIAN FOODSTUFFS VIA SOME TRADITIONAL COOKING METHODS AND STORING IN ALUMINUM PANS

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ABSTRACT: *Aluminum migration from aluminum vessels into some foodstuffs as a result of traditional Egyptian cooking processes were studied. Also, the migration of aluminum via holding of the previously cooked peas, potatoes and spinach in the same containers were evaluated. The results indicated that traditional cooking processes increased significantly ($p < 0.05$) the aluminum content of all studied foodstuffs. This increase was higher in the acidic and salty foods than that in non-acidic ones. Also, the acidic and salty foods leached more aluminum into foodstuffs during the cold storage (at 4°C for 48hr) of cooked foods. Generally, foods cooked with tomatoes and salt and holded for 48hr in an aluminum vessel had the highest aluminum content followed by those cooked with tomatoes, then those cooked with salt and lastly those cooked without any additives.*

Key word: *Aluminum migration, spinach, peas, potatoes, cooking methods, aluminum vessels, cold storage.*

INTRODUCTION

Aluminum has been regarded as harmless for healthy human beings until recently. In the literatures, however, orally-consumed aluminum is increasingly considered as a contaminant of the food chain, playing a role in the etiology of neurodegenerative disease like Morbus Alzheimer and Amyo Trophic Lateral Sclerosis (Candy *et al.*, 1986; Mclachlan *et al.*, 1989; Martyn *et al.* 1989 and Flaten, 1990). General possibilities of oral aluminum exposure of humans occur via foodstuffs, extensive use of aluminum-containing food additives, migration of aluminum from saucepan or food packaging into foodstuffs, and also drinking water (Muller *et al.* 1998). On average, a person's daily aluminum intake is approximately 20mg/day via the gastro intestinal tract and 3-5 mg/day via inhalation (Birchall and Chappell, 1988). Foods with high values of aluminum are those foodstuffs with a content of greater than 1mg aluminum containing additives and those prepared or stored over a length of time in aluminum vessels (Vela *et al.* 1998). These food that tend to be strongly acidic (pH 3) or slightly basic (pH 3-7) tends to leach the most aluminum from containers (Samsahl and Wester, 1977). Gaballah, (2000) observed that the acidic and salted foods resulted in greater migration of aluminum into the products and care should be taken when using aluminum containers with acidic and salty foods. Therefore, the purpose of this study is to determine the aluminum migration rate into some Egyptian foods via traditional cooking methods and also due to cold storage (at 4°C) of such foods in the same vessels for 48hrs.

MATERIALS AND METHODS

Materials:

Green Peas, Potatoes, Tomatoes and Spinach were purchased in July 2002 from the local market of Shibin El-Kom city.

Methods:

Technological methods:

Tomatoes were blended in a blender. Potatoes were washed in tap water then manually peeled, cut into 5.0 x 0.7 x 0.7 cm. pieces using mechanical cutter (Type Chef, La Minorca, Italy) and quickly submerged in the water. Spinach was cut into small pieces using a kitchen knife. Peas were manually peeled. Potatoes, spinach and peas were cooked (either alone or with 1% NaCl, with tomatoes and with both tomatoes and 1% NaCl) in aluminum vessels for 30 min. Cooked vegetables were stored in aluminum containers in the refrigerator at (4°C) for 48hrs. and the aluminum content was determined at various time intervals(each 12hr).

Aluminum determination:

The fresh and previously cooked foodstuffs were homogenized in a blender and dried to a constant weight at (105°C), dry ashed in a muffle furance at 500°C and dissolved in diluted hydrochloric acid (1 M). Aluminum determination was carried out by atomic absorption (Perkin Elmer, Germany) as described by Muller *et al.* (1998).

Determination of pH:

Determination of pH values were carried out using digital pH meter (Jenway UK).

Statistical analysis

Results are expressed as the mean values of three replicates. Data were subjected to analysis of variance using a completely randomized design. Differences between any two means were determined using LSD with a $P \leq 0.05$ significance level (Steel and Torrie, 1980)

RESULTS AND DISCUSSION

As shown in Table 1, the traditional cooking processes increased significantly ($P \leq 0.05$) the aluminum content with an increasing rate of 33.33, 41.11, 45,55 and 51.1% for cooked peas, cooked peas with salt, cooked peas with tomato and cooked peas with both tomato and salt, respectively. Peas cooked with tomatoes and NaCl had the highest aluminum content (1.31µg/gm) then that cooked with salt (1.27µg/gm). Muller *et al.* (1993)

reported that acidic products such as tomatoes puree dissolved considerable amounts of Al during conventional cooking in uncoated aluminum pans.

Table (1): Effect of different traditional cooking methods on aluminum migration into cooked peas.

Technological treatments	Al. µg/gm FM	% increase of AL	PH
Peas	0.9 c		7.3
Cooked peas	1.20 b	33.33	7.21
Cooked peas + salt*	1.27 b	41.11	7.70
Cooked peas + tomatoes	1.31 ab	45.55	6.21
Cooked peas + tomatoes + salt*	1.36 a	51.11	6.94

FM = Fresh matter
Means in the same column with different letters are significantly different ($p \leq 0.05$)
* = 1% NaCl

Aluminum content of potatoes increased significantly ($P \leq 0.05$) after cooking process (Table 2). The highest increase was observed when potatoes cooked with tomatoes and salt (48.33%) followed by that cooked with tomato (41.11%) and then that cooked with salt (29.4%). Whereas no significant ($P > 0.05$) differences were noticed between that cooked with tomatoes and that cooked with both tomatoes and salt. Also, addition of salt during potato's cooking processes has no significant effect. Gaballah (2000) stated that acidic and salt foods increased the aluminum migration into foodstuffs as a result of enhancing chemical and/or electro-chemical corrosion.

Table (2): Effect of different traditional cooking methods on aluminum migration into cooked potato

Technological treatments	Al. µg/gm FM	% increase of AL	PH
Potatoes	1.8 c		7.70
Cooked potatoes	2.20 b	22.22	7.40
Cooked potatoes + salt*	2.33 b	29.44	7.73
Cooked potatoes + tomatoes	2.54 a	41.11	6.35
Cooked potatoes + tomatoes + salt*	2.67 a	48.33	6.96

FM = Fresh matter
Means in the same column with different letters are significantly different ($p \leq 0.05$)
* = 1% NaCl

The same trend was observed in cooked spinach with a higher aluminum content (Table 3). It was increased significantly ($P \leq 0.05$) via cooking processes, The highest increase was noticed in spinach cooked with both tomatoes and salt (50.6%) followed by that cooked with tomatoes (43.75%). Also, addition of salt during cooking processes has no significant ($P > 0.05$) effects, this could be due to addition of salt don't markedly change the pH. The high aluminum content of fresh spinach (as a leafy vegetable) other than peas and potatoes could be due to the high capacity of these plants to accumulate the metal in there leaf tissues, as well as its larger leaf areas exposed to atmospheric dust (Onianwa *et al.*, 1997).

Table (3): Effect of different traditional cooking methods on aluminum migration into cooked spinach

Technological treatments	Al. µg/gm FM	% increase of AL	PH
Spinach	3.20 c		5.62
Cooked spinach	4.10 b	28.13	5.73
Cooked spinach + salt*	4.30 b	34.38	5.91
Cooked spinach + tomatoes	4.60 ab	43.75	5.22
Cooked spinach + tomatoes + salt*	4.82 a	50.62	5.87

FM = Fresh matter
Means in the same column with different letters are significantly different ($p \leq 0.05$)
* = 1% NaCl

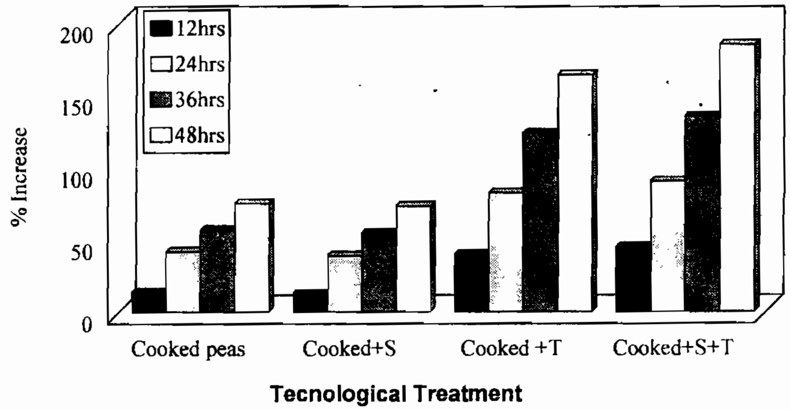
Effect of cold storage in aluminum migration

Cold storing (4°C) of previously cooked green peas increased significantly ($P \leq 0.05$) aluminum content, except both peas cooked without any additives and that cooked with salt after 12hrs (Table 4 and Fig 1). Cooked peas stored for 48hrs contained the highest aluminum content. Regarding to the aluminum content, it can be arranged in the following decreasing order, peas cooked with tomatoes and salt (3.88 µg/gm), peas cooked with tomatoes (3.46µg/gm), peas cooked with salt (2.20µg/gm) and finally that cooked without any additives (2.10µg/gm).

Table (4) : Effect of cold storage (at 4°C for 48hr) of cooked peas on aluminum migration

Technological treatments	Al. µg/gm FM				
	0 hr	**12 hrs**	**24 hrs**	**36 hrs**	**48 hrs**
Peas	0.9				
Cooked peas	1.20 d	1.36 cd	1.70 b	1.88 b	2.10 a
Cooked peas + salt*	1.27 e	1.43 de	1.76 c	1.96 b	2.20 a
Cooked peas + tomatoes	1.31 e	1.83 d	2.39 c	2.93 b	3.46 a
Cooked peas + tomatoes + salt*	1.36 e	1.97 d	2.59 c	3.20 b	3.88 a

FM = Fresh matter
Means in the same row with different letters are significantly different ($p \leq 0.05$)
*** = 1% NaCl**



S= Salt
T= Tomatoes

Fig 1. Increase(%) in aluminum content of cooked peas after cold storage for 48hrs.

The same trend was observed in cooked potatoes stored for 48hrs (Table 5 and Fig 2). Generally, aluminum content of cooked potatoes increased significantly ($p \leq 0.05$) after the storage. The highest increasing rates of aluminum contents were noticed in potatoes cooked with both tomatoes and salt and stored for 48hrs (179.4%), followed by that cooked with tomatoes (148.33%) and then that cooked with salt (121.46%).

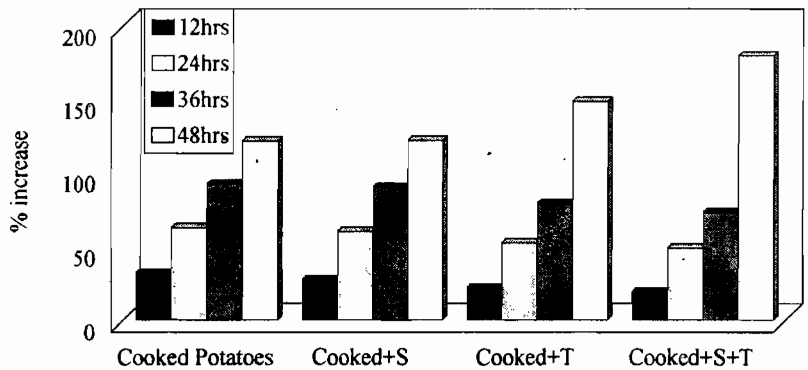
Table (5): Effect of cold storage (at 4°C for 48hr) of cooked potatoes on Aluminum migration

Technological treatments	Al. µg/gm FM				
	0 hr	12 hrs	24 hrs	36 hrs	48 hrs
Potatoes	1.8				
Cooked potatoes	2.20 e	2.90 d	3.57 c	4.21 b	4.86 a
Cooked potatoes + salt*	2.33 e	2.97 d	3.72 c	4.41 b	5.16 a
Cooked potatoes + tomatoes	2.54 e	3.10 d	3.87 c	4.53 b	6.30 a
Cooked potatoes + tomatoes + salt*	2.67 e	3.19 d	3.98 c	4.61 b	7.46 a

FM = Fresh matter

Means in the same row with different letters are significantly different ($p \leq 0.05$)

* = 1% NaCl



S=Salt

T=Tomatoes

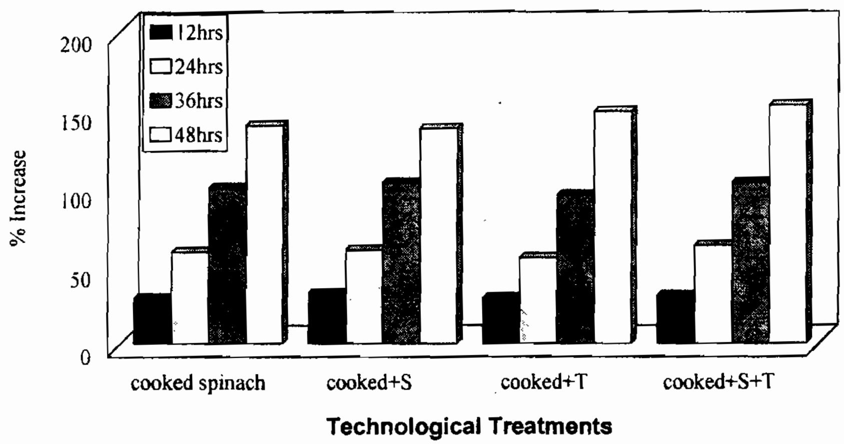
Fig 2. Increase(%) in aluminum content of cooked potatoes after cold storage for 48hrs.

On the other hand, significant ($P \leq 0.05$) increases were observed in cooked spinach after cold storage (Table 6 and Fig. 3). Cooked spinach with tomatoes and salt had the highest aluminum content after storing for 48hrs (12.14µg/gm) followed by that cooked with tomatoes (11.43µg/gm), then that cooked with salt (10.20µg/gm) and lastly that cooked without any additives (9.80µg/gm). Meanwhile, the increasing rate after 48hrs was higher in cooked spinach without additives (139.02%) than that cooked with salt (137.20%). This increase was lower than that observed after storing of both peas and potatoes for the same time this may be due to fresh spinach contained aluminum higher than the other vegetable both. Generally, high migration rates of aluminum in foods can be attributed to the chemical corrosion by acids or alkalis during boiling for short time in aluminum vessels, and the electro-chemical corrosion when foods are left in contact with aluminum vessels for long periods (Vela *et al.*,1998 and Gaballah, 2000).

Table (6) : Effect of cold storage (at 4°C for 48hr) of cooked spinach on Aluminum migration

Technological treatments	Al. µg/gm FM				
	0 hr	12 hrs	24 hrs	36 hrs	48 hrs
Spinach	3.20				
Cooked spinach	4.10 e	5.30 d	6.50 c	8.16 b	9.80 a
Cooked spinach + salt*	4.30 e	5.70 d	6.87 c	8.70 b	10.20 a
Cooked spinach + tomatoes	4.60 e	5.95 d	7.11 c	8.94 b	11.43 a
Cooked spinach + tomatoes + salt*	4.82 e	6.30 d	7.83 c	9.75 b	12.14 a

FM = Fresh matter
Means in the same row with different letters are significantly different ($p \leq 0.05$)
* = 1% NaCl



S=Salt
T=Tomatoes

Fig 3. Increase(%) in aluminum content cooked spinach after cold storage for 48hrs.

CONCLUSION

From the previous results it could be concluded that all traditional Egyptian cooking methods in aluminum vessels increased the aluminum migration to such vegetables, *i.e.* peas, potatoes and spinach, where the lowest pH the highest aluminum migration occurs. In addition, the prolongation of foodstuffs storage time in aluminum vessels the increases accumulation of aluminum ions.

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انتقال الألومنيوم إلى بعض الأغذية المصرية خلال عمليات الطبخ التقليدية والتخزين في أواني من الألومنيوم

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الملخص العربي

تعد الأواني الألومنيوم المستخدمة بصورة كبيرة في مصر أحد أهم ملوثات المواد الغذائية بالألومنيوم والذي ثبت دوره في إحداث بعض الأمراض مثل (الزهايمر). وقد هدف هذا البحث إلى دراسة تأثير طرق إعداد الطعام التقليدية المصرية على هجرة الألومنيوم من الأواني إلى المادة الغذائية، و كذلك تم دراسة انتقال الألومنيوم خلال تخزين هذه الأغذية في نفس الأواني داخل الثلاجة (على ٤°م لمدة ٤٨ ساعة). وقد أكدت النتائج ما يلي:

١-أن عمليات الطهي التقليدية في الأواني الألومنيوم قد زادت من محتوى الألومنيوم في المواد الغذائية المطبوخة معنويا.

٢- أظهرت الأغذية المنخفضة في رقم الحموضة والمضاف إليها ملح متبوعة بتلك المنخفضة في رقم الحموضة بدون ملح محتوى أكبر من الألومنيوم بعد الطهي.

٣- أظهرت نفس الأغذية المنخفضة في رقم الحموضة مع إضافة الملح تأثيرا أكبر في هجرة الألومنيوم من الأواني إلى المادة الغذائية أثناء التخزين في الثلاجة لمدة ٤٨ ساعة مما يعنى أن انخفاض رقم الحموضة وكذلك إضافة الملح يؤدى إلى زيادة معدل هجرة الألومنيوم من الأواني إلى المواد الغذائية.

و بناء عليه فإنه ينصح باستخدام الأواني الزجاجية بدلاً من تلك المصنوعة من الألومنيوم في إعداد أو تخزين المواد الغذائية .