Effect of Cooking on Aluminium Migration to Meats Wrapped in Aluminium Foil Under Resturant Conditions

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ABSTRACT

Cooking of wrapped meats in aluminium foil is a common practice applied in many resturants, fast food outlets and hotels. However, there is concern araised recently regarding the toxicity of aluminium and its relations to some diseases (mainly chronic renal failure, various bone (osteomalacia) and neurological failures (Alzhemier's disease).

The effect of different cooking treatments (150 °C for 60 min, 200°C for 40 min, and 250 °C for 20 min) on aluminium (Al) contents in red meats (beef, water buffalo, sheep) and white meats (chicken and turkey) cooked in aluminium foil were studied. Data revealed that cooking elevated Al concentrations of both red and white meats. The increase was 10.20–83.0% in red meats and 12.20–75% in poultry. The least increase was observed in the samples cooked at 150 °C for 60 min, while the highest increase was traced in samples cooked at 250 °C for 20 min.

It can be concluded that the cooking processes affected the migration of Al and thereby cooked meats wrapped in aluminium foil may carry a risk to human health. Therefore,data of the present study can be a guide for resturants, fast food outlets and hotels to avoid wrapping of meats in aluminium foils prior to cooking, and use glass utensils for food cooking instead of aluminium foil in order to prevent contamination of meats with aluminium.In case of wrapping meats in aluminium foil, it is advisable to apply low cooking temperature for long time (i.e. 150 °C for 60 min.). Data presented here indicated that such a treatment results in a decline of migration rate of Al from foil to food.

INTRODUCTION

Cooking of wrapped meats in aluminium foil is a common practice applied in many resturants, fast food outlets and hotels. Nowadayes, there is a significant concern about aluminium toxicity in patients with longstanding chronic renal failure (Meiri *et al*.,1993) and associated with various bone (osteomalacia) and neurological failures (Alzhemier's disease) (Gauthier *et al*., 2000; Rondeau *et al*., 2000; Grant *et a*l, 2002; Polizzi *et al*., 2002; Miu *et al*., 2004; Gupta *et al*., 2005). Also, the consumption of foodstuffs with high levels of metals can cause gastric irritation and diarrhea (WHO, 1982; Blunden and Wallace, 2003) and affect multiple organ systems.

Aluminium (Al) has a variety of industrial applications because of its attractive properties such as low specific gravity, high thermal and electric conductivity, attractive appearance, its corrosion resistance and easy processing properties (Ranau *et a*l., 2001; Joshi *et al*., 2003). Aluminium is widely used for manufacturing household utensils and packaging materials. Aluminium foil is widely used for packaging, storing, and cooking of various foods. In addition, it is common practice to wrap meat and fish and cook them in the oven in order to prevent water uptake (McWilliams, 1989) and avoid direct heat (Ranau *et al*., 2001).

The extent of Al leaching into foods cooked in aluminium utensils or wrapped with aluminium foil was strongly related to several factors such as the type of aluminium utensils, pH of the food and/or cooking medium, form and composition of food, the old of utensils, duration of contact/cooking and presence of fluoride (Rajwanshi *et a*l.,1999; Yaman *et al*., 2003, Scancar *et al*., 2004). In recent years, it is a common practice to wrap the meat to oven cooking and the possible relation between Al uptake and the potential effects of it, therefore the present study was conducted to detect the levels of Al content in different red meats (beef, water buffalo, sheep) and white meats (chicken and turkey) wrapped with aluminium foil and cooked in an oven at three different temperature/time periods (150 °C for 60 min, 200 °C for 40 min, and 250 °C for 20 min).

MATERIALS AND METHODS

Sampling and Cooking

Fresh red meats of beef, water buffalo and sheep (muscles and livers) and white meats of chicken and turkey (breast and legs) were purchased from the local market in Alexandria. Egypt and immediately transferred to the laboratory. Samples from each species were trimmed to remove bones, skin and surface fat, cut into small pieces and then divided into portions. Samples (200 g for each) were wrapped in aluminium foil (30 × 30 cm, thickness 12 mm) and cooked under

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Received November 6, 2007, Accepted December26, 2007

resturant conditions in an electrical oven (1200 W, 220 V, 50-60 Hz) at 150 °C for 60 min, 200 °C for 40 min and 250 °C for 20 min . At the same time, raw samples without cooking were analyzed for comparison. The raw and cooked samples were ground in a glass mortar to ensure homogeneity and subjected for metal analysis. Homogenized samples of each species were individually analyzed in triplicates.

Sample Preparation for Aluminium Analysis

Sample preparation was performed according to the method of NIOSH (1994) with slight modifications. In this method, 1g of each sample was transferred to a beaker containing 10 ml of digestion acid (nitric acid, sulfuric acid and perchloric acid in ratios of 3:1:1, respectively). The mixture was heated overnight at 110 °C and then at 250 °C until 1 ml of mixture remained (2-3 hrs). The solution was left to cool and the contents of the beaker were transferred to a volumetric flask and diluted with 10% sulfuric acid to 5 ml. A blank was prepared in the same fashion. All reagents were of analytical-reagents grade and deionized water (pH 7.0) of 15 MΩ.cm resistivity obtained from a water purification system (PURELAB Option-R, ELGA, UK) was used throughout the study.

Determination

Standard of Al metal solution (1000 µg/ml) was obtained from J. B. Baker Inc. (Phillipsburg, NJ, USA). Metal was measured by using atomic absorption spectrometer (AAS, Shimadzu Model AA-6200, Kyoto, Japan) at a wavelength of 309.3 nm, equipped with a hollow cathode lamp, a 10 cm long slot-burner head and a nitrous oxide-acetylene flame. The operating conditions adjusted in the spectrometer were carried out according to the standard guidelines of the manufacture. Blank solution was prepared under identical conditions and the average signal was subtracted from analytical signals of samples. Working solutions were prepared directly from the metal standard solution (1000 mg/l) before determination. The solution concentration for Al in the sample Cs (µg/ ml), and the average blank, Cb (µg/ml) were obtained from the measurement data. The final solution volumes of samples Vs (ml) and blank, Vb (ml) were used. The concentration, C (µg/g) of each sample in the mass of sample taken, M (g) was calculated as follows: C (µg/g) = (CsVs - CbVb)/M. Three standard concentrations, 0, 0.25 and 0.5 µg of metal stock solution (1000 µg/ ml), were added to 1 g of sample and then digested as described previously to calculate recoveries.

Results are expressed as mg/kg of fresh meat. Detection limits are defined as the concentration corresponding to three times the standard deviation of ten blanks. Detection limit value of Al was 0.10 mg/ kg. The percentages of recovery ranged from 93 to 100%.

Statistical Analysis

Data were calculated as mean ± standard deviation (SD) analyzed using analysis of variance (ANOVA). Probability of 0.05 or less (P< 0.05) was considered significant. The statistical package of Costat Program (Costat 1986) was used for all chemometric calculations.

RESULTS AND DISCUSSION

The levels of Al for raw and red meats cooked under different conditions and wrapped in aluminium foil are given in Table 1. The effects of cooking treatment on Al contents of red meats were significant (P< 0.05). The contents of Al in raw muscle beef (Fig.1-A,B) increased from 20.20 to 24.50 mg/kg at 150 °C for 60 min, 28.67 mg/kg at 200 °C for 40 min, and 33.60 mg/kg at 250 °C for 20 min. In case of liver beef, the levels of Al were 25.4, 32.60, 38.70 and 45.00 mg/kg for raw, cooking at 150 °C for 60 min, 200 °C for 40 min and 250 °C for 20 min, respectively. Also data in Table 1 illustrate that , Al levels were 16.22, 17.88, 21.50 and 25.88 mg/kg in muscles of water buffalo and 23.50, 30.42, 35.66, 40.50 mg/kg in livers of water buffalo for raw , cooking at 150 °C for 60 min, 200 °C for 40 min and 250 °C for 20 min, respectively (Fig.2-A,B).

For muscles of sheep (Fig.3-A,B) , Al levels increased from 10.44 in raw to 13.33, 16.25 and 19.16 mg/kg when cooked at 150 °C for 60 min, 200 °C for 40 min and 250 °C for 20 min, respectively. For liver samples, the levels of Al were found to increase from 15.34 in raw to 19.22, 23.33, 27.90 mg/kg when cooked at 150 °C for 60 min, 200 °C for 40 min and 250 °C for 20 min, respectively.

Data in Table 2 show that cooking treatments significantly affected the Al contents of poultry meats (P < 0.05). As in the case of red meats, the lowest Al content was observed in the raw meats and the highest in those cooked at 250 °C for 20 min. For cooked chicken breast, chicken leg (Fig.4-A,B) , turkey breast and turkey leg (Fig.5-A,B) wrapped in aluminium foil, Al contents increased by 12.2, 14.8, 21.7 and 24.3% at 150 °C for 60 min; 32.8, 37.5, 41.3 and 43.4% at 200°C for 40 min, and 41.1, 59.7, 68 and 75% at 250 °C for 20 min, respectively. Therefore, the least increase was traced in the samples cooked at low temperature for a long time (150 °C for 60 min) while the highest increase was recorded for the samples cooked at a high temperature for a short time (250 °C for 20 min).These results are in agreement with Turhan (2006) who found that cooking temperature is more important in Al leaching than cooking time.

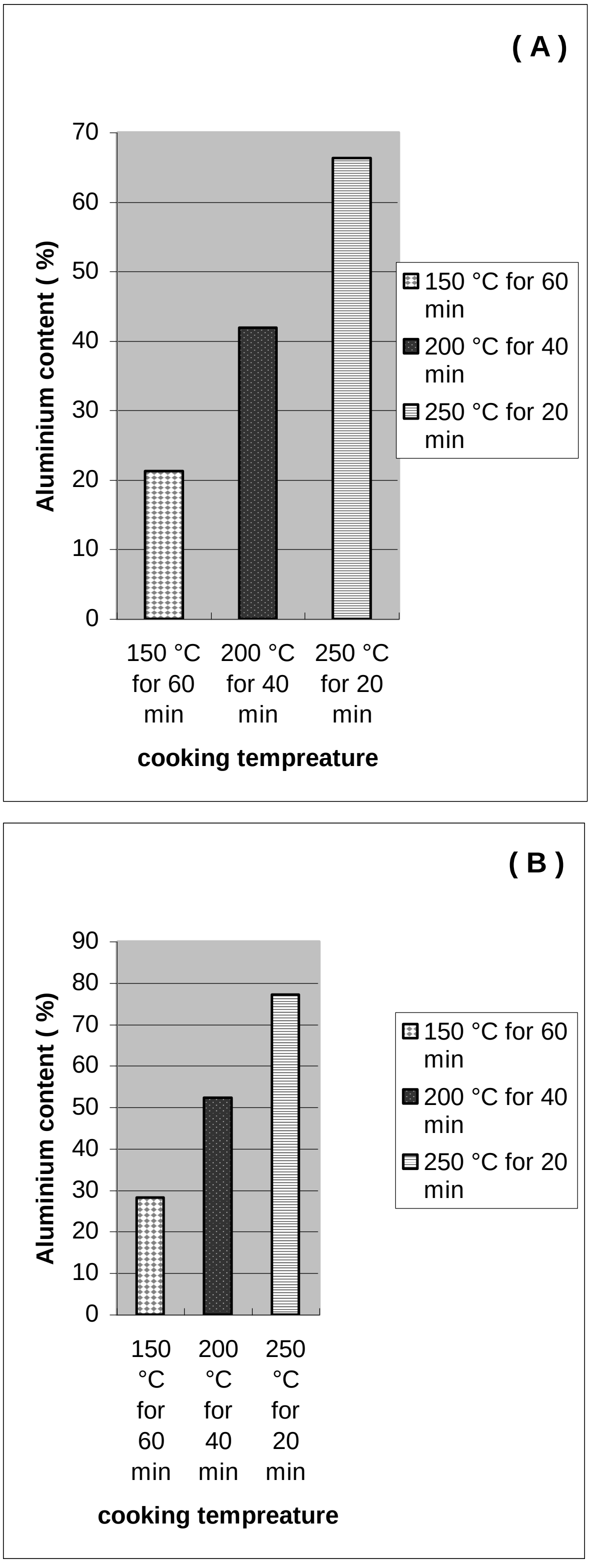


Fig.1.Effect of cooking conditions on Al content of Beeff
(A): Muscles (B): liver

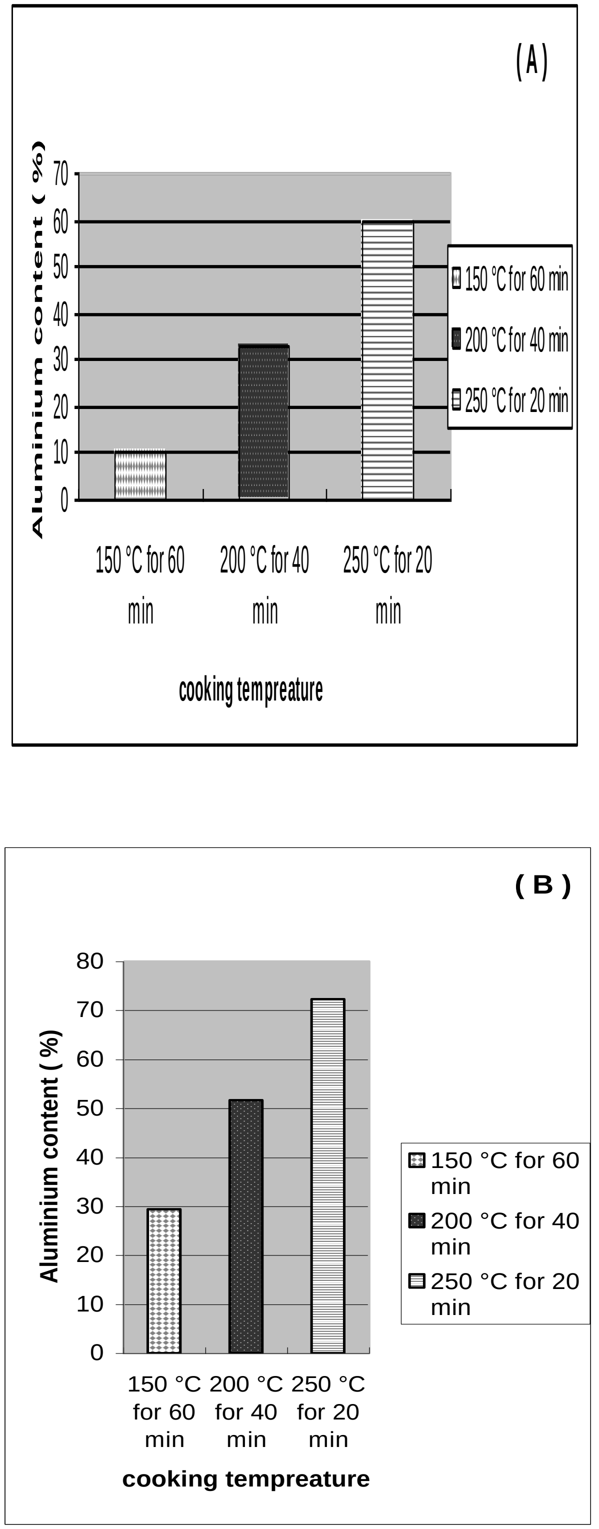


Fig.2. Effect of cooking conditions on Al content of Water buffalo
(A): Muscles (B): liver

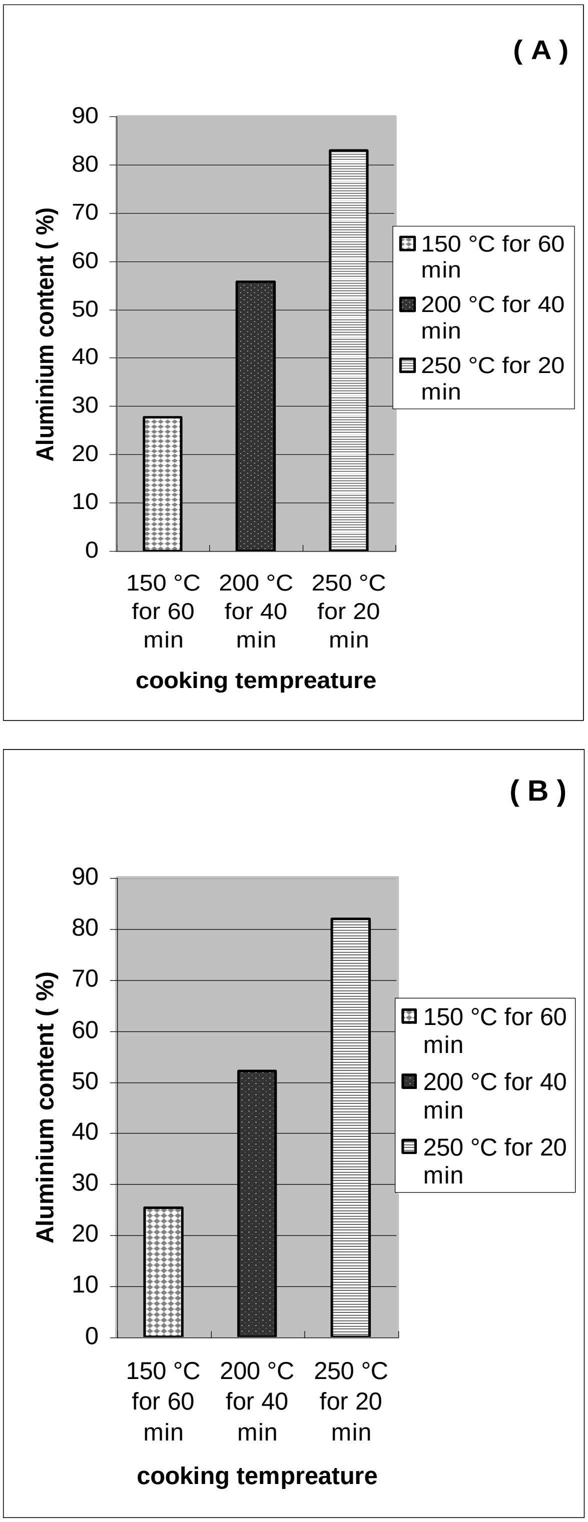


Fig.3. Effect of cooking conditions on Al content of Sheep

(A): Muscles (B): live

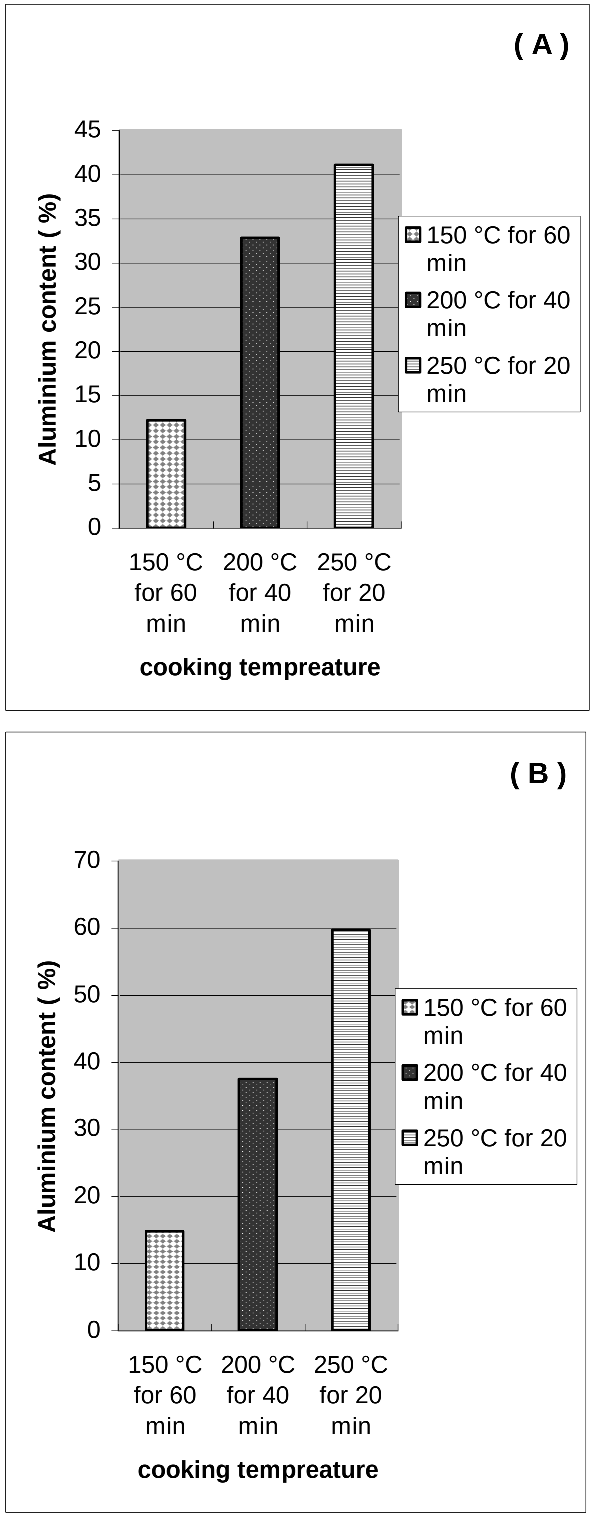
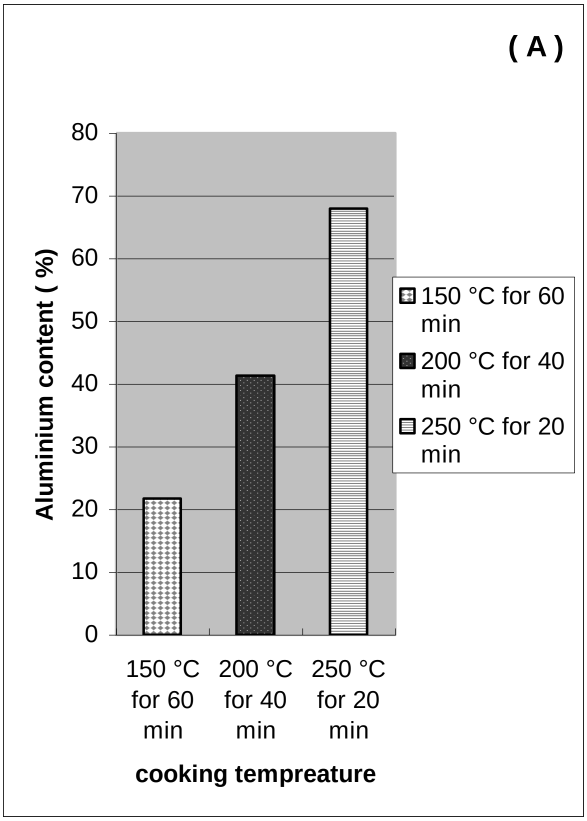


Fig. 4. Effect of cooking conditions on Al content of Chicken

(A): Breast (B): Leg



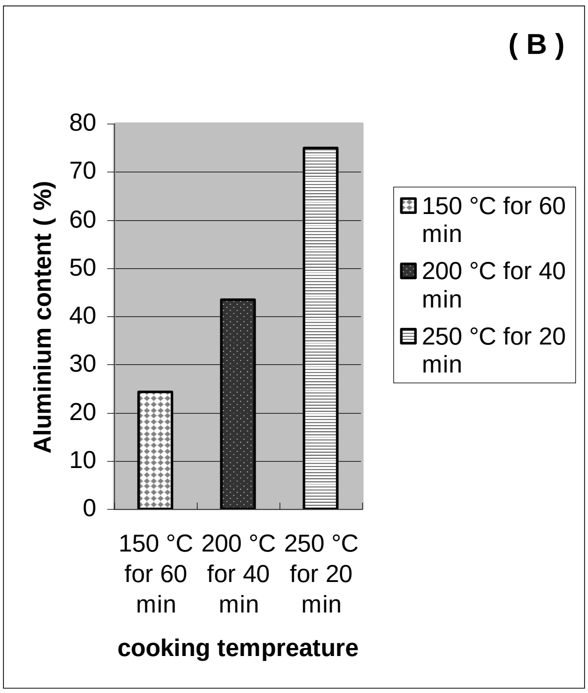


Fig.5. Effect of cooking conditions on Al content of Turky

(A): Breast **(B): Leg**

This may be explained on the basis that the higher cooking temperature stimulated the leaching of Al from foil to meats, because at elevated temperatures, the oxide layer becomes thicker and changes from an amorphous to a crystalline structure (Rajwanshi *et al.*, 1997).

Ranau *et al*. (2001) found that the Al concentration of wrapped and cooked fillets was higher than samples cooked in an oven at 200 °C. In addition, cooking in aluminium utensils increased Al concentration of foods (Greger *et al*., 1985; Watanabe and Dawes, 1988; Gramiccioni *et al*., 1996; Fimreite *et al*., 1997; Yaman *et al.*, 2003 ; Scancar *et al.*, 2004).Meanwhile, Gramiccioni *et al*. (1996) found that Al concentration of 'meat cannelloni' prepared in aluminium cookware increased by 25%. Also, greater increase in Al contents was found in sauerkraut and sour turnip stating that aluminium utensils are not suitable for acidic foods (Scancar *et al*., 2004)

The increase in Al concentrations of muscles sheep (27.7% at 150 °C for 60 min, 55.7% at 200 °C for 40 min, and 83% at 250 °C for 20 min) after cooking were significantly higher than their counterparts in both beef and water buffalo muscles .In contrast, the Al content increment of liver sheep (81.9%) was significantly higher than beef (77.2%) and water buffalo (59.6%) cooked at 250°C for 20 min. For the red meats, livers had significantly higher Al contents than muscles. Also, the raw beef muscles and livers had significantly higher Al contents than the raw water buffalo and sheep muscles and livers. In case of poultry, the increase in Al concentrations of breast and leg of turkey was significantly higher than breast and leg of chicken after cooking either at 150 °C for 60, 200 °C for 40 min or 250 °C for 20 min. This variation may be due to the chemical composition of meats (Turhan, 2006).

In addition, raw chicken and turkey- breast meats had higher significantly Al contents than both raw chicken and turkey leg meats. This finding shows that poultry- breast meats store more Al than leg meats do.

CONCLUSION

The present investigation indicated that cooking in aluminium foil increase the Al content of either red or white meats. It was found that migration of ingredients from active packaging into food stuffs may occurred (Lopez-Cervantes *et al.*, 2003;, Osman and Al-Rehiayani, 2006). This may present a potential threat to health, security and safety of such food items to unsuspecting consumer. .Aluminium contents ranged from 10.44 to 25.40 mg/kg in raw red meats and 13.33 to 45.00 mg/kg in cooked red meats, while it ranged from 17.05 to 25.23 mg/kg in raw poultry meats, and

21.20 to 35.60 mg/kg in cooked poultry meats. In all tested samples, the lowest increase in Al levels was observed in the samples cooked at 150 °C for 60 min, while the highest levels were found in samples cooked at 250 °C for 20 min.

Regarding the suggested provisional tolerable daily intake of 1 mg Al/kg body weight/day (FAO/WHO, 1994), it can be stated that there is no evident risk to the health of consumer. However, it is possible that excessive consumption of foods wrapped with aluminium foil may carry a health risk because cooking processes affect the migration of aluminium.

Data of the present study can be considered as a guide for resturants, fast food outlets and hotels to avoid wrapping of meats in aluminium foils prior to cooking, and use glass utensils for food cooking instead of aluminium foil in order to prevent contamination of meats with aluminium.Notwithstanding, if there is no way to use aluminium foil in wrapping of meats, it is advisable to apply low cooking temperature for a long period (i.e. 150 °C for 60 min.). Such a treatment results in a decline the migration rate of Al from foil to food.

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الملخص العربي

تأثير عمليات الطهي على انتقال معدن الألمونيوم للحوم المغلفة برقائق الألمونيوم تحت ظروف الطهي بالمطاعم

خالد أحمد عثمان و هالة حسن السيد

يعتبر طهى اللحوم بعد تغليفها برقائق الألمنيوم من الممارسات الشائعة فى المطاعم ومنافذ بيع الأغذية السريعة والفنادق ، وحيث أن هناك أدلة علمية تشير إلى سمية الألومونيوم وارتباطه بالعديد من الأمراض من أهمها الفشل الكلوى وأمراض العظام والزهايمر، فقد عنيت هذه الدراسة بتقدير محتوى الألمنيوم فى بعض أنواع اللحوم حيث تم دراسة تأثير بعض عمليات الطهي المستخدمة فى المطاعم والمتمثلة في استخدام درجات حرارة مختلفة للطهي ولفترات زمنية مختلفة على انتقال معدن الألمنيوم للحوم الحمراء (بقري و جاموسي و غنم) و للحوم البيضاء (دجاج و رومي) تم تغليفها في رقائق الألمنيوم، حيث تم استخدام درجة حرارة 150°م لمدة 60 دقيقة و 200°م لمدة 40 دقيقة و 250°م لمدة 20 دقيقة. أوضحت النتائج أن جميع ظروف عمليات الطهي المختبرة قد أدت إلى زيادة معنوية في تركيز عنصر الألمونيوم سواء في اللحوم الحمراء أو البيضاء حيث بلغت هذه الزيادة نسبة قدرها 10.20-83% و 12.20-75% في اللحوم الحمراء و البيضاء، على التوالي.

كما أوضحت النتائج أن أقل زيادة في محتوي اللحوم من عنصر الألمونيوم كانت للحوم التي تم طهيهاعلى درجة حرارة 150°م و لمدة 60 دقيقة، بينما تبين أن أعلى تركيز كان موجودا في اللحوم التي تم طهيها على درجة حرارة 250°م و لمدة 20 دقيقة. ويمكن القول بأن عمليات الطهي تؤثر فعلاً على انتقال عنصر الألمونيوم وأن التغذية على وجبات مغلفة في رقائق من الألمونيوم ثم طهيها قد يمثل بالفعل خطورة على صحة الإنسان. ولذا توصي الدراسة الحالية باستخدام الأواني الزجاجية في عمليات طهي الأطعمة بدلاً من استخدام رقائق الألمونيوم لتقليل تلوث الأطعمة بعنصر الألمونيوم. وفى حالة صعوبة الاستغناء عن رقائق الألمنيوم فى تغليف اللحوم المزمع طهيها، فإنه ينصح بإجراء عملية الطهى عند درجة حرارة منخفضة ولمدة أطول (أى 150°م لمدة 60 دقيقة) حيث أن مثل هذه المعاملة تؤدى إلى خفض معدل انتقال الألمونيوم من رقائقه إلى الغذاء المغلف بها، وهو ما أوضحته هذه الدراسة.