The effects of aluminum utensils and cooking methods on concentrations of aluminum in raw (control) and cooked beef samples were studied. Beef was wrapped in aluminum foil and cooked in boiling water with pieces of onion and stored at 4°C for interval periods 0, 12, 24, 36 and 48 hour. Cooking was done in electrical oven for 60 min. at 120°C, for 40 min. at 180°C and for 20 min. at 240°C. Aluminum residues were found in all the samples. The average concentration of aluminum in raw beef were 0.28 mg/kg (wt/w), meanwhile the average level of aluminum in cooked beef wrapped in aluminum foil for 60 min. at 120°C were 0.34 mg/kg (wt/w). Cooked beef had a significant higher (P<0.05) aluminum levels in compared to control samples due to migration of aluminum from aluminum foil and aluminum utensils to meat. Under all experimental trials, the highest aluminum concentration levels were observed in beef cooked with onion (1.90 mg/kg) and the lowest concentrations were observed in beef cooked by boiling without adding any ingredients (0.30 mg/kg). The obtained results confirmed that increase in cooking time and in cooking temperature significantly increase (P<0.05) the aluminum concentrations levels of cooked beef wrapped in aluminum foil. Aluminum utensils should be avoided from cooking of meat. Cooking of beef wrapped in aluminum foil at 120°C for 60 min. is recommended to safe consumers from the hazards of aluminum residues.

INTRODUCTION

Aluminum(Al) is the third most abundant element in the Earth's crust and is a non-essential element to which humans are frequently exposed (Tria at al., 2007). Al is wide spread through nature, air water, plants and consequently in all the food because of its uses. The metal
enters the human system mainly through food, drugs, cosmetics, drinking water and beverages (Ekanem et al., 2009).

Aluminum has deleterious effects on the central nervous, skeletal and hematopoietic systems of humans (Miu et al., 2004). The neurotoxicity of Al to patients with chronic renal diseases is well established and its presence in the bloodstream leads to Al accumulation in bone and brain causing an encephalopathy called dementia dialysis (Klei, 2005). It is also associated with neurological disorders in patients on long-term parenteral nutrition and preterm infants receiving intravenous feedings (Klein, 2003). It has been suggested, that low-level long term exposure to all may be a contributing factor in Alzheimer's diseases (Falten, 2001 and Tabrizi, 2007). The total aluminum content arises from food containers such as cans, cookware, utensils and food wrappings. It has been established that cooking of acidic and low acidic foods in aluminum saucepans or foil causes leaching of the metal (Sadetin, 2006). Food which were manufactured and stored in aluminum cans, showed an increased aluminum content. High levels of aluminum in foods can be attributed to chemical corrosion by acids or alkalis during boiling for short period in aluminum vessels, electrochemical corrosion when foods are left in contact with aluminum vessels for long period, acidic and salty food increasing concentration of complexing ions (Qiong et al, 2006, Denis and Morgana, 2008). The extent of the increase of aluminum is dependent on factors such as temperature, PH value, duration of contact or heating, presence of sugar, organic acids, salt and other ions (Ranau et al,2009).

The average daily intake of aluminum for adult men, women, 6-11 month old infants and 14-16 years old males is 8.9, 7, 0.7 and 11.5 mg/day respectively (Becke et al.,1990).

This study was conducted to detect the levels of aluminum content in meat cooked in aluminum utensils with different methods and stored refrigerator for different periods and also in meat packed with aluminum foil and cooked in electric ovens at three different temperature and time periods.
Materials and Methods

1-Sampling

Sixty samples of raw beef meat were collected from Qena markets. The fresh red meat samples were trimmed to remove bone and fat and then cut into small pieces.

2-Experimental design:

The samples were divided into two groups (30 of each) The weight of each sample in the first group was 900 gm. The first group were divided into three subgroups (300 gm of each). "A" was the control (raw meat), "B" was the raw meat cooked in boiling water in aluminum utensils, while "C" was the raw meat cooked in boiling water with onion in aluminium utensils, subgroup B and C were cooked till complete cooking, then cooled and stored at frigidaire at 4°C in aluminum pan for 48 hours and analyzed for their aluminum content after 0, 12, 24, 36 and 48 hrs. The raw meat and raw onion were analysed for aluminium content before cooking. The weight of the second group (30 samples) was 400 gm and divided into four subgroups, each 100 gm. Subgroup (1) was the control (raw meat) subgroup (2) was wrapped in aluminum foil and baked in an electrical oven at 120 °C for 60 minutes, subgroup (3) was wrapped in aluminum foil and baked in an electrical oven at 180 °C for 40 minutes while the subgroup (4) was wrapped in aluminum foil and baked in an electrical oven at 240 °C for 20 minutes.

3- Digestion and analysis of samples:

The samples were minced, homogenized and analyzed for aluminum content by the wet oxidation method according to A.O.A.C. (1990) by using Perkins Elmer 2380 Atomic Absorption Spectrophotometer at wave length 309, temperature 2900-3000 °C with nitrous oxide and acetylene.

N.B: All reagents were of analytical grade and deionized water was used. Glassware was washed in concentrated Hcl and rinsed with deionized water.
4- **Statistical analysis:**

The obtained data were statistically analyzed according to the method recommended by Petrie and Watson (1999).

**Results**

The levels of aluminum (mg/kg wet weight) in raw and cooked beef meat in boiling water in aluminum pan were illustrated in table (1).

The levels of aluminum (mg/kg wet weight) in raw onion, beef and cooked meat with onion on aluminum pan were recorded in table (2). Aluminum contents in raw and baked beef meat wrapped in aluminum foil were shown in table (3).

### Table (1) Levels of aluminium (mg/kg wet weight) in raw and cooked beef meat in boiling water in aluminium pan

<table>
<thead>
<tr>
<th>Storage Time</th>
<th>Min.</th>
<th>Max.</th>
<th>X ± S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw beef meat (control)</strong></td>
<td>0.142</td>
<td>0.339</td>
<td>0.287 ± 0.749</td>
</tr>
<tr>
<td><strong>After end of cooking (zero time)</strong></td>
<td>0.095</td>
<td>0.162</td>
<td>0.131 ± 0.448</td>
</tr>
<tr>
<td>After 12 hrs</td>
<td>0.139</td>
<td>0.198</td>
<td>0.178 ± 0.240</td>
</tr>
<tr>
<td>After 24 hrs</td>
<td>0.157</td>
<td>0.249</td>
<td>0.203 ± 0.789</td>
</tr>
<tr>
<td>After 36 hrs</td>
<td>0.192</td>
<td>0.291</td>
<td>0.264 ± 0.526</td>
</tr>
<tr>
<td>After 48 hrs</td>
<td>0.278</td>
<td>0.334</td>
<td>0.307 ± 0.329</td>
</tr>
</tbody>
</table>

Min: Minimum values.
Max: Maximum values.
X: Mean values.
± S.E: Standard Error.
Control samples: raw beef meat before cooking.
Table (2) Levels of aluminium (mg/kg wet weight) in raw onion, raw beef meat and cooked beef meat with onion in aluminium pan

<table>
<thead>
<tr>
<th>Storage Time</th>
<th>Min.</th>
<th>Max.</th>
<th>X ± S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw onion</td>
<td>0.0005</td>
<td>0.0027</td>
<td>0.0012 ± 0.003</td>
</tr>
<tr>
<td>Raw beef meat (control)</td>
<td>0.142</td>
<td>0.339</td>
<td>0.287 ± 0.749</td>
</tr>
<tr>
<td>After end of cooking (zero time)</td>
<td>0.384</td>
<td>0.521</td>
<td>0.453 ± 0.721</td>
</tr>
<tr>
<td>After 12 hrs</td>
<td>0.562</td>
<td>0.687</td>
<td>0.632 ± 0.650</td>
</tr>
<tr>
<td>After 24 hrs</td>
<td>0.598</td>
<td>0.783</td>
<td>0.716 ± 0.959</td>
</tr>
<tr>
<td>After 36 hrs</td>
<td>0.634</td>
<td>0.843</td>
<td>0.789 ± 0.968</td>
</tr>
<tr>
<td>After 48 hrs</td>
<td>0.691</td>
<td>1.952</td>
<td>1.902 ± 1.996</td>
</tr>
</tbody>
</table>

Table (3) Aluminium contents (mg/kg wet weight) in raw and baked beef meat wrapped in aluminium foil

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Min</th>
<th>Max</th>
<th>X ± S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.163</td>
<td>0.281</td>
<td>0.237 ± 0.504</td>
</tr>
<tr>
<td>2</td>
<td>0.241</td>
<td>0.389</td>
<td>0.349 ± 0.560</td>
</tr>
<tr>
<td>3</td>
<td>0.332</td>
<td>0.482</td>
<td>0.417 ± 0.728</td>
</tr>
<tr>
<td>4</td>
<td>0.421</td>
<td>0.612</td>
<td>0.526 ± 0.792</td>
</tr>
</tbody>
</table>

Treatment (1): Control group (raw beef meat)
Treatment (2): Raw meat wrapped in aluminium foil and backed in oven at 120°C for 60 minutes.
Treatment (3): Raw meat wrapped in aluminium foil and backed in oven at 180°C for 40 minutes.
Treatment (4): Raw meat wrapped in aluminium foil and backed in oven at 240°C for 20 minutes.

No. of examined samples = 30.

**DISCUSSION**

The obtained data in table (1) showed the aluminum levels of beef meat cooked in boiling water in aluminum pan, where time "O" is the time of complete meat cooked while 12, 24, 36 and 48 hrs are times of storage of meat in refrigerator at 4°C in aluminum pan. The mean values were 0.131, 0.178, 0.203, 0.264 and 0.307.
mg/kg respectively. When compared with raw meat (0.287 mg Al/kg), a decrease in the level of aluminum was observed, but there was an increase in Al content in beef samples with the increase of storage time, this because migration of aluminum from aluminum pan into food simulating solvents. All parameters, the type of solvent, the temperature and the time of storage affected the magnitude of aluminum dissolution. The aluminum migration into acidic solvents when heated at temperature 95°C for 30 minutes, was higher than into tap water (Takeda et al, 1998). The obtained data were lower than those reported by Diab (2005) and Ekanem et al (2009). Table (2) showed the levels of aluminum pan content in meat cooked with Onion in aluminum and stored at different periods in refrigerator, when compared with raw meat, all samples increased in its aluminum content after cooking and storage. On the basis of these data, it could be concluded that acidic and salted foods increased the migration of aluminum into foods as the result of enhancing chemical and electrochemical corrosion. These data are in accordance with those reported by Gramiccione et al. (1996) and Diab (2005) who reported the highest release of aluminum into acidic and salted foods from cookware. Also, Mei and Yao (1994) reported that aluminum concentration increased due to chemical corrosion by acids and alkalis during boiling and storage for short periods.

The recorded data in table (3) showed that the aluminum content in raw beef increased from 0.237 to 0.349 mg/kg at 120°C for 60 minutes, 0.417 mg/kg at 180°C for 40 minutes and 0.526 mg/kg at 240°C for 20 minutes. Therefore, the least increase was in samples cooked at low temperature for a long time (120°C for 60 min.) and the highest increase was in samples cooked at high temperature for a short time (240°C for 20 min.). The obtained data were lower than those reported by Sadettin (2006) and Ekanem et al (2009). These results suggest that cooking temperature is more important in aluminum leaching than cooking time. This may be explained that the higher cooking temperature stimulated the leaching of aluminum from foil to meats, because at elevated temperature, the oxide layer becomes thicker and changes from an
amorphous to a crystalline structure (Rajwanshi et al., 1997, Ranau et al., 2001). Other researchers stated that cooking in aluminum utensils increased the aluminum concentration of foods (Yaman et al., 2003 and Scancar et al., 2004).

In conclusion, it could be concluded that beef meat cooked in boiling water appeared to be the best one because the amount of aluminum was low. Regarding the suggested provisional tolerable daily intake of 1 mg Al/kg body weight per day of the World Health Organization, 1989 and FAO/WHO Expert Committee on Food Additives (FAO/WHO, 1994), there is no evident risk to the health of the consumer from eating 200 gm daily of cooked meat prepared in aluminum pan and care should be taken when using aluminum containers for storage of food because of the health risks associated with high aluminum intake. However, it is possible that excessive consumption of foods packed with aluminum foil may carry a health risk.

REFERENCES


FAO/WHO (1994): Summary evaluations performed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA)


بقايا الألومنيوم في اللحم البقر المغلف برقائق الألومنيوم والمطهي عند درجات الحرارة المختلفة

جهان رجب محمد داود
قسم الرقابه الصحيه على الاغذية – كلية الطب البيطري- جامعة جنوب الوادي – قنا - جمهورية مصر العربية

الملخص العربي
تم دراسة تأثير الأوعيه الألومنيوم وطرق الطهي على تركيز الألومنيوم في عينات اللحم البقرى (المجمعة الضابطة) واللحوم البقرى المطهي وقد تم تغليف اللحم البقري برقائق الألومنيوم والمطهي في المثل المغلب مع بعض قطع البصل والتخزين عند درجه حرارة 4 مئوية على فترات مختلفه (صفر، 12، 24، 36، 48 ساعه) وقد تم متابعة عمله المطهي في الفرن الكهربائي لمدة 10 دقائق عند 200 درجة مئوية ولمدة 40 دقيقة عند 180 درجة مئوية ولمدة 20 دقيقة عند 140 درجة مئوية.

وقد وجدت بقایا الألومنيوم في كل العينات حيث كان متوسط تركيز الألومنيوم في عينات اللحم البقرى (العينات الضابطة) ، 0.28 مجم/كجم وكان متوسط مستوي الألومنيوم في عينات اللحم البقرى المطهي المغلف برقائق الألومنيوم لمدة 0.20 دقيقة عند 120 درجة مئوية كان 0.04 مجم/كجم وكان لمستويات تركيز الألومنيوم في اللحم المطهي تأثير معنوي على من 0.05 بالإضافة إلى الاقارئ بالعينات الضابطة نتيجة هجره الألومنيوم من رقائق الألومنيوم والأوعيه الألومنيوم الى اللحم البقرى وقد لوحظ أن أعلى تركيز للألومينيوم قد وجد في اللحم المطهي بالصلب(1.95 مجم/كجم) واقل تركيز لوحظ في اللحم البقرى المطهي بالغليان بدون أي اضافات (0.20 مجم/كجم).

وقد أكدت النتائج أن الزيادة في وقت الطهي ودرجة حرارة الطهي قد أدت الى زيادة تركيز مستوي الألومنيوم في اللحم البقرى المطهي والمغلف برقائق الألومنيوم ولذلك يجب تجنب طهي اللحم في الأوعية الألومنيوم ونصح بطهي اللحم البقري المغلف برقائق الألومنيوم عند درجة حرارة 120 درجة مئوية لمدة 0.20 دقيقة حيث يعتبر امن للمستهلكين من مخاطر بقایا الألومنيوم.