MIGRATION OF IRON AND ALUMINUM FROM DIFFERENT COOKWARES TO FABA BEAN AFTER COOKING CYCLES AND STORAGE REFRIGERATED

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ABSTRACT

Metals supply for humans is fullfiled from food stuffs. This process is affectd by many factore i.e. cooking, packaging and handling. The aim of this work is to investigate the migration of iron and aluminum from cookware to cooked faba bean and we choosed faba bean because it high content of iron metal and it need long time for cooking. Cookwares used for the experiment were aluminum, stainless steel and enameld steel. Iron and aluminum metals were analyzed in faba bean before and after cooking for three cycles and upon storage for one week. Results revealed that aluminum

migrated from aluminum cookware to cooked faba bean as it was increased from 22.29 to 43.2 mg/kg in faba bean at the second cooking cycle. For other cookwares no migration for aluminum metal after cooking. Also iron metal migrated from all cookwares to cooked faba bean, iron migrated from aluminum cookware to cooked faba bean as it was increased from 53.5 to 66.96 mg/kg at the second cooking cycle. In case of enameled and stanless steel cookwares iron migrated as it was increased from 53.5 to 115.5 mg/kg at the third cooking cycle in enameld cookware and increased from 53.5 to 77.3 mg/kg at the first cooking cycle in stainless steel cookware. Study the migration of iron and aluminum after storage for 7 days at 3oc the results indicated the occurrence of the migration of iron and aluminum metals in some cooking cycles and decreasing in some other cooking cycles.

Key words: Migration; Elements; Cookwares.

INTRODUCTION

There are many accusations of cooking utensils for metals migration to foods. It is noticeable that the cooking utensils which are made from aluminum, iron, pottery, stainless steel are containing metals such as Al and Fe. Migration of elements from cookwares to food depends on the pH of food, length of cooking period and type of cookware (Grger, 1985).(Parkar and Rakesh, 2014) studied the migration of iron and aluminum from packaging materials to canned foods under different conditions of temperature, acidity and storage period. The results show an increase of iron and aluminum concentration. (Arora, 2000) mentained that the addition of some acidic substances such as tomatoes and dates juice is the reason of the migration of the iron content from the packaging materials. The study was based on the type of cookwares, the number of cooking cycles and storage period in the same cookware. (Lisiewska *et al*., (2008) studied the content of P, K, Ca, Mg, Na, Fe, Cu, Mn, Cr, and Ni before and after ashing on the beans food and storage for 12 months at 30oc, increasing the content of the elements using traditional cooking.

Studies have shown that nature of cookwares, cooking process, storage can increase trace metal level in food. Heavy metals are potential environmental contaminants with the capabilities of causing human health problems if present in food at high concentration, the type of cooking utensil used may contribute some considerable amount of trace elements into food by way of leaching (Nnorom, 2007). High Al content was found in the brain of persons with Alzheimer 's disease, and as food is actually the primay source of Al intake for humans (soni*et al*., 2001), Al migration from food contact materials is nowadays of great concern, Industrial processes, food preparation and various sources of drinking water may be exposed to the toxic effects of metals (Klasen, 1990).(Jarup 2003; Sathawara*et al.*, 2004,) reported that heavy metals in general are not biodegradable, have a long biological half-life and also the possibility of accumulation in various organs of the body, leading to side effects undesirable. Increasing concentration of trace elements in the body may cause disorders related to the bones, brain and blood. Ingestion of food is a clear way of exposure to metals, and not only because many of the minerals and natural elements of the food but also because of environmental pollution and contamination during processing. (Damont *et al.*, 2012) studied the effect of pH, the nature of the acid and temperature on immigration trace elements of ceramic deal with 18 glass coating available commercially. Besides lead and cadmium, migration of toxic elements and other such as aluminum, boron, barium, cobalt, chromium, copper, iron, lithium, magnesium, manganese, nickel, antimony, tin, strontium, titanium, vanadium, zinc and zirconium in order to evaluate their potential health risks. At low pH (2 <pH <3), and the nature of the acid plays an important role.Citric and malic acid seems to be more aggressive on the glaze than smooth surface of acetic acid with the exception of aluminum, barium, chromium, iron and magnesium. Dynamic migration between pH 2 and 3 degrees in the acetic acid from these exceptions is more exponential while other elements of linear regression been decreasing. In ceramics used in this study (fired in 900oc), it observed a linear relationship between migration and temperature.Immigration seen from the free elements toxic steel pots cooking polished to unconditional food the cooking in solution is suitable for the connection food if allowed to emigrate from boron levels, fluorine cobalt and nickel exceed 2.5, 0.5, 1.0 and 1.0 mg / L, respectively (Gioevaya *et al*., 1982).

This work aims at studying the migration of iron and aluminum metals from aluminum, enameld and stainless steel cookwares to fababean after three cooking cycles and storage for 7 days.

MATERIALS AND METHODS

1- Materials:

A- Cookwares: Three kinds of cookwares were used in the study those were aluminum, stainless steel andenameld cookwares. Before each use, all utensils were thoroughlywashed by hot water and detergent, rinsed well with tap water and air dried.

B- Faba bean: Faba bean was purchased from local market at Sharkia governorate, Egypt. Including (local faba bean).

C- Chemicals and reagents: All chemicals, including nitric acid (69%, Honeywell), perchloric acid (70%, Oxford), stock standards (Merck, 1000 mg/L) for Fe and Al were commercially purchased. Deionized water was obtained from Millipore unit made in france.

METHODS

1) Preparation of sample: Using tap water and fixed amount of faba bean (1 kg) were cooked in three types of utensils which are aluminum, stainless steel and enameld cookwares. Faba bean was cooked about 8 hours in the three utensils and in the same utensil three cycles, then it was stored at 3oC 7 days with adding citric acid with random way.A homogenized sample was completely dried over night in an air oven at 105oC, then subjected to metal analysis

2) **Elemental analysis:** Metals in this study were analysed using Inductively coupled plasma (ICP) (Optima 2000 Dv made in U.S.A) according to official method (AOAC, 2012).

3) **pH of cooked food:** Using Metrohm pH meter (thermo made in U.S.A), pH of faba bean was measured after cooking, cooling, homogenization.The pH of the resulting solution was measured after making the appropriate calibration of the pH meter using to bracketing buffer solutions (pH 4 and pH 7).

RESULT AND DISSCUTION

In the current work, a precise model was used to investigate the possible migration of Al and Fe metals from cookwares to faba bean. Thus, after cooking and after storing. Faba bean was analyzed for metal concentration as shown in tables (1-3).

Table (1), presented the migration of Fe and Al metals from aluminum cookware to faba bean after cooking three cycles and after storing for 7 days. As showen in table (1) results pointed out that it was happened migration for iron metal as it was increased from 53.5 to 60.6 mg/kg after cookingwith a statistically significant at differences ($p<0.05$) and from 60.6 to 60.87 after storing with non statistically significant in cycle one, iron was increased from 53.5 to 66.96 mg/kg after cooking with non significant at differences (p>

0.05) and decreased from 66.96 to 62.45 mg/kg after storingwith a statistically significantat differences ($p<0.05$) in cycle two, iron was increased from 53.5 to 57.3 mg/kg after cookingwith a statistically significant at differences ($p<0.05$) and it was increased from 57.3 to 63.14 mg/kg after storing with a statistically significanat differences ($p<0.05$) in cycle three. Aluminum metal was increased from 22.29 to 26.4 mg/kg after cooking with non significant at differences ($p>0.05$)and from 26.4 to 30.98 mg/kg after storingwith a statistically significant at differences ($p<0.05$) in cycle one, aluminum was increased from 22.29 to 43.2 mg/kg after cookingwith a statistically significantat differences ($p<0.05$) and decreased from 43.2 to 40.07 mg/kg after storing with non significant at differences ($p<0.05$) in cycle two, aluminum was increased from 22.29 to 31.6 mg/kg after cookingwith a statistically significant at differences ($p<0.05$) and from 31.6 to 36.87 mg/kg after storing with a statistically significant at differences ($p<0.05$)in cycle three. (Cheng and Brittin, 1991) confirmed other previous research that foods cooked in iron utensils were greater in iron content than foods cooked in non-iron utensils. (Greger *et al*.,1985) reported that tomatoes heated in aluminum pans for a few minutes accumulated only 0.02- 0.03 mg Al/100 g serving, while tomato sauces cooked for 3 hours in aluminum pans accumulated 5.7mg Al/100g serving. (Zhan *et al*., 2015) studied the migration of metals from ceramic pan to acidic foods and storage food in short time (24h) at 20-40oC the migration of metals was failed, but in long time (600h) the migration of metals was increased.

Table (1): Concentration of Fe and Al metals in faba bean before and after cooking in aluminum utensil for three cycles and after storing for 7 days.

Cooking cycles	**Fe**	**Al**	pH
Raw faba bean	53.5d±0.4	22.29d±2.19	6.3
Cycle one after cooking	60.6bc±2.2	26.4d±1.1	5.67
cycle one after storing for 7 days	60.87bc±1.97	30.98c± 0.88	4.2
Cycle two after cooking	66.96a±1.26	43.2a±1.4	5.6
Cycle two after storing for 7 days	62.45b±0.75	40.07ab±0.57	4.5
Cycle three after cooking	57.3c±1.0	31.6c±2.4	5.65
Cycle three after storing for 7 days	63.14b±0.74	36.87b±1.67	4.02

Means of the same letter(s) in the same column are not significantly different ($p > 0.05$).

Raw faba bean mean :faba bean before cooking.

Table (2), study the migration of Fe and Al metals from enameld cookware to faba bean after cooking three cycles and after storing for 7 days. As showen in table (2) results pointed out that it was happened migration for iron metal as it was increased from 53.5 to 54.6 mg/kg after cooking with non significant at differences ($p>0.05$) and from 54.6 to 55.12 after storing with non significant at differences ($p>0.05$) in cycle one, iron was increased from 53.5 to 77.6 mg/kg after cookingwith a statistically significant at differences ($p<0.05$) and decreased from 77.6 to 63.19 mg/kg after storing with a statistically significantat differences ($p<0.05$) in cycle two, iron was increased from 53.5 to 115.5 mg/kg after cooking with a statistically significant at differences ($p<0.05$) and it was decreased from 115.5 to 71.3 mg/kg after storingwith a statistically significant at differences ($p<0.05$) in cycle three. Aluminum metal was decreased from 22.29 to 10.0 mg/kg after cookingwith a statistically significantat differences ($p<0.05$) and it was increased from 10.0 to 14.8 mg/kg after storing with a statistically significant at differences ($p<0.05$) in cycle one, aluminum was decreased from 22.29 to 19.06 mg/kg after cooking with a statistically significant at differences ($p<0.05$) and decreased from 19.06 to 17.7 mg/kg after storing with non significant at differences ($p>0.05$) in cycle two, aluminum was decreased from 22.29 to 18.5 mg/kg after cooking with a statistically significantat differences ($p<0.05$) and from 18.5 to 13.6 mg/kg after storing with a statistically significant at differences ($p<0.05$) in cycle three, also the migration of Al metal was decreased due to the hydrothermal abilities and usage in the electroplating of other metals (Temidayo, 2011). (Tassi *et al.*, 2014) studied the migration of Cu, Cr, Cd, Al, Fe, Mn, Ni, and Pb from carbon steel cylinders to food gases and stored up to 50 day, the migration was lower for metals. (Quintaes *et al.*, 2006) studied the migration of Fe, Mg, Mn, Cr, Ni, and Ca from Brazilian pans to rice and tomato sauce at 7 cooking cycles the result pointed out migration of the metals.A hot leach method published by the World Health Organization for determining Pb and Cd in ceramic and enameled ware was collaboratively studied in 14 laboratories. The method consisted of heating a solution of 4% acetic acid at the boil for 2 h in 6 samples of specially glazed ceramic ware and 6 samples of special enameled ware. The acid was allowed to cool and stand in contact with the ware for an additional 22 h. At the end of the 2 h heating period and again at the end of the 24 h period, the leach solution was assayed by atomic absorption spectrophotometry for Pb and Cd.The quantity of Pb and Cd released from enameled ware increased linearly with time during 7 h of boiling(Gould *et al*., 1983).

Table (2): Concentration of Fe and Al metals in faba bean before and after cooking in enameld utensil for three cycles and after storing for 7 days.

Cooking cycles	Fe	Al	pH
Raw faba bean	53.5e±0.4	22.29a±2.19	6.3
Cycle one after cooking	54.6e±0.8	10.0d±0.8	5.9
cycle one after storing for 7 days	55.12e±0.62	14.8c±0.16	3.9
Cycle two after cooking	77.6b±0.9	19.06b±0.9	5.5
Cycle two after storing for 7 days	63.19d±0.99	17.7b±0.4	4.2
Cycle three after cooking	115.5a±1.2	18.5b±0.7	5.6
Cycle three after storing for 7 days	71.3c±1.0	13.6c±0.8	4.5

Means of the same letter(s) in the same column are not significantly different ($p > 0.05$).

Raw faba bean mean : faba bean before cooking.

Table (3), study the migration of Fe and Al metals from stainless steel cookware to faba bean after cooking three cycles and after storing for 7 days. As showen in table (3) results pointed out that the migration for iron metal as it was increased from 53.5 to 77.3 mg/kg after cookingwith a statistically significant at differences ($p<0.05$) and it was decreased from 77.3 to 56.7

after storing with a statistically significant at differences ($p<0.05$) in cycle one, iron was increased from 53.5 to 55.7 mg/kg after cooking with non significant at differences ($p>0.05$) and increased from 55.7 to 66.5 mg/kg after storing with a statistically significantat differences ($p<0.05$) in cycle two, iron was increased from 53.5 to 61.97 mg/kg after cooking with a statistically significant at differences ($p<0.05$) and it was decreased from 61.97 to 57.04 mg/kg after storing with a statistically significantat differences ($p<0.05$) in cycle three. Aluminum metal was decreased from 22.29 to 19.6 mg/kg after cooking with non significant at differences ($p>0.05$) and from 19.6 to 12.8 mg/kg after storing with non significant at differences ($p>0.05$) in cycle one, aluminum was decreased from 22.29 to 14.3 mg/kg after cooking with a statistically significant at differences ($p<0.05$) and decreased from 14.3 to 13.8 mg/kg after storing with non significant at differences ($p>0.05$) in cycle two, aluminum was decreased from 22.29 to 13.96 mg/kg after cooking with a statistically significant at differences ($p<0.05$) and from 13.96 to 12.3 mg/kg after storing with non significant differences ($p<0.05$) in cycle three, also the migration of Al metal was decreased due to the hydrothermal abilities and usage in the electroplating of other metals (Temidayo, 2011). Temidayo (2011) studied how cadmium and chromium leach into the food we eat. Results were generated from the study of the ratios of cadmium and chromium contamination of food boiled in steel and stainless steel pots using Flame Atomic Absorption Spectrophotometry (FAAS). Cadmium was leached from new stainless steel and not detected in new steel pots, but for the old and very old stainless steel pots and steel pots, which gave 0.093±0.02µg/g and 0.045±0.020µg/g for old and very old steel pots, while 0.079±0.01µg/g and 0.092±0.01µg/g for old and very old stainless steel pots, cadmium leached beyond the control concentration. No leaching of chromium was detected in new stainless pots and steel pots, as well as, old and very old pots. (Buculei *et al*., 2011) studied the migration of Cu, Al, Mn, Fe, Zn, and Cr from packaging in beer during storage 6 months at 26-28 co, the content of metals was decreased.

Table (3): Concentration of Fe and Al metals in faba bean before and after cooking in stainless steel utensil for three cycles and after storing for 7 days.

Cooking cycles	Fe	Al	pH
Raw faba bean	53.5d±0.4	22.29a±2.19	6.3
Cycle one after cooking	77.3a±1.5	19.6ab±0.8	5.7
cycle one after storing for 7 days	56.7d±1.5	12.8b±1.0	4.2
Cycle two after cooking	55.7d±0.6	14.3b±0.7	5.8
Cycle two after storing for 7 days	66.5b±1.07	13.8b±0.68	4.1
Cycle three after cooking	61.97c±1.03	13.96b±0.3	6.00
Cycle three after storing for 7 days	57.04d±0.9	12.3b±0.3	4.06

Means of the same letter(s) in the same column are not significantly different ($p > 0.05$).

Raw faba bean mean : faba bean before cooking.

CONCLUSION

The results of the study showed that the iron metal was migrated from all the cooking utensils and the aluminum element was transferred from the aluminum cookware onlyand migration in some cycles and no migration in other cycles after storing for 7 dyas.

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هجرة الحديد والألومنيوم من أواني طهي مختلفة الى الفول بعد دورات طهي مختلفة وتخزين مبرد

[٣]

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المستخلص

يهدف هذا البحث الى دراسة هجرة الحديد والألومنيوم من أواني الطهي المختلفة الى الفول المطهي، تم تحليل عنصري الحديد والألومنيوم قبل طهي الفول وبعده وبعد التخزين المبرد لمدة أسبوع، أشارت النتائج الى حدوث انتقال عنصر الألومنيوم من اناء الألومنيوم الى الفول المطهي حيث زاد من ٢٢,٢٩ الى ٤٢,٢ مللجم/كجم في دورة الطبخ الثانية أما باقي الأواني لم يحث انتقال لعنصر الألومنيوم أيضا انتقل الحديد من جميع أواني الطهي الى الفول المطهي، حيث انتقل عنصر الحديد من اناء الألومنيوم الى الفول حيث زاد من ٥٣,٥ الى ٦٦,٩٦ مللجم/كجم في الدورة الثانية للطبخ، أما في حالة اناء الصلب غير القابل للصدأ والصاج فقد زاد انتقال الحديد من ٥٣,٥ الى ١١٥,٥ في الدورة الثالثة للطبخ في اناء الصاج، وزاد من ٥٣,٥ الى ٧٧,٣ مللجم/كجم في الدورة الأولى في اناء الصلب غير القابل للصدأ، دراسة انتقال الألومنيوم والحديد بعد التخزين لمدة أسبوع عند درجة حرارة ٣ °C فقد أشارت النتائج الى حدوث انتقال في بعض دورات الطبخ وعدم حدوث انتقال في البعض الآخر.