Determination of the levels of lead and cadmium in canned fish and meat, imported to the local markets of Diyala Province, Iraq

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Abstract

Food of animal origin is among those products that provide many important nutrients. The food industry employs numerous technologies which allow manufacturing of products with diversified shelf life. The objective of the study was to determine the contents of lead (Pb) and cadmium (Cd) in 49 samples of canned fish and meat from different brands by using the flame atomic absorption spectroscopy (FAAS). It was found that the highest mean of lead in canned fish was 0.2294 ± 0.00014 mg / kg, while the lowest mean was 0.0214 ± 0.00049 mg / kg, the highest mean of cadmium in canned fish was 0.2322 ± 0.00686 mg / kg and the lowest was 0.1170 ± 0.00021 mg / kg. The highest mean of lead in chicken and beef meat was 0.2454±0.03486 mg/ kg, while the lowest mean was 0.0217 ± 0.00057 mg/ kg. For cadmium, the highest mean in chicken and beef meats was 0.3091 ± 0.00014 mg / kg and the lowest was 0.1214 ± 0.00021 mg / kg. The statistical analysis showed that there were significant differences (p≤0.05) between the studied samples for each element. Lead values in the tested samples varied between values above the acceptable limits recommended by the WHO or within the global limits, while the cadmium values for all tested samples exceeded the acceptable limits adopted by the WHO.
INTRODUCTION

Food of animal origin is among those products that provide many important nutrients. The food industry employs numerous technologies which allow manufacturing of products with diversified shelf life. Canned products are characterized by a long shelf life, do not need to be kept at low temperature, and do not require special treatment during transport or distribution [1]. The topics “food quality” and “food safety” are very close and two important issues in the food sector, due to the globalization of the food supply and the increased complexity of the food chain. The consumers need to purchase safe products that do not involve any kind of risk for health and food safety is a major public concern worldwide, during the last decades, the increasing demand of food safety has stimulated research regarding the risk associated with consumption of food stuffs contaminated by pesticides, heavy metals and/or toxins [2]. The aim of the “food safety” is to avoid health hazards for the consumer: microbiological hazards, pesticide residues, misuse of food additives and contaminants, such as chemicals, biological toxins and adulteration. While the “food quality” includes all attributes that influence the value of a product for the consumer; this includes negative attributes such as spoilage, contamination with filth, discoloration, off-odors and positive attributes such as the origin, color, flavor, texture and processing method of the food [3].

Heavy metal pollution, such as lead and cadmium, is a human-made pollution [4]. Therefore, it has become an issue of concern due to its persistent nature in the environment [5]. Heavy metals are distributed in the environment through many natural processes such as volcanic eruptions, spring water, erosion, bacterial activity, and through human activities that include fossil fuel combustion, industrial processes, agricultural activities, as well as nutrition [6].

The objective of the study was to determine the contents of lead and cadmium in 49 samples of canned fish and meat from different brands by using the flame atomic absorption spectroscopy (FAAS).

MATERIALS AND METHODS

Samples collection

In total, 49 samples have been investigated and as follow: canned tuna (n=22), sardine (n=6), chicken luncheon (n=11), and canned beef (n=10) purchased from local markets of Baquba city, the capital city of Diyala Province in the middle of Iraq, during 2019 (Tables 1 and 2). Canned foods were transported to the laboratory, labeled, and stored at room temperature in a clean dry place until being used.

Sample preparation and reagents

The meat was removed from the can and left at room temperature (25°C), washed with distilled water, homogenized with a mixer. Two grams from each sample were selected with three replicates, placed in a 100ml glass beaker, then a solution of hydrochloric acid (37% HCl) as a solvent after dilution with deionized water at a ratio of (1: 2), the samples were placed on electric heater at a temperature of 180 ºC for two hours to complete the digestion. A mixture of 37% HCl and nitric acid (HNO3) at a concentration of 65% (royal water) at a ratio of (3: 1) was added and then the mixture was placed on the electric heater at a temperature of 150 ºC, and then the samples were left to cool down at laboratory temperature. The samples were transferred to 25ml volumetric flask after filtration and the volume was completed by adding the deionized water and thus, the samples were ready for measurement by an atomic absorption device [7].
Standards

Standard stock solutions containing 1000 mg/L of each element (Cd and Pb) were obtained from the Ibn Sina Center / Ministry of Industry and Minerals /Iraq. The purity of the starting material in standards was 99.99% for each element. For qualitative analysis of the samples, a five-point calibration curve (including zero) was constructed.

Determination the concentrations of cd and pb

The concentrations of the lead and cadmium in the fish and meat samples were determined by using the flame atomic absorption spectroscopy (FAAS), Analytic Jena NOV AA 350 / Germany.

Statistical Analysis.

Data were analyzed by SPSS for windows TM version 24.0. Statistical analysis of data was performed using t-test and one-way ANOVA. All experimental data were presented as mean ± SD. A p-value less than 0.05 was considered statistically significant.

Table 1: Characteristics of the tested canned fish.

| Sample code | Fish type      | Number of samples analyzed |
|-------------|----------------|---------------------------|
| F1          | Tuna in oil    | 3                         |
| F2          | Tuna in oil    | 3                         |
| F3          | Tuna in oil    | 3                         |
| F4          | Tuna in oil    | 3                         |
| F5          | Tuna in oil    | 3                         |
| F6          | Tuna in oil    | 3                         |
| F7          | Tuna in oil    | 3                         |
| F8          | Tuna in oil    | 3                         |
| F9          | Tuna in oil    | 3                         |
| F10         | Tuna in oil    | 3                         |
| F11         | Tuna in oil    | 3                         |
| F12         | Tuna in oil    | 3                         |
| F13         | Tuna in oil    | 3                         |
| F14         | Tuna in oil    | 3                         |
| F15         | Tuna in oil    | 3                         |
| F16         | Tuna in oil    | 3                         |
| F17         | Tuna in oil    | 3                         |
| F18         | Tuna in oil    | 3                         |
| F19         | Tuna in oil    | 3                         |
| F20         | Tuna in oil    | 3                         |
| F21         | Tuna in oil    | 3                         |
| F22         | Tuna in oil    | 3                         |
| F23         | Sardine in oil | 3                         |
| F24         | Sardine in oil | 3                         |
| F25         | Sardine in oil | 3                         |
| F26         | Sardine in oil | 3                         |
Table 2: Characteristics of the tested canned meat.

| Sample code | Meat type            | Number of samples analyzed |
|-------------|----------------------|----------------------------|
| M1          | Chicken luncheon meat| 3                          |
| M2          | Chicken luncheon meat| 3                          |
| M3          | Chicken luncheon meat| 3                          |
| M4          | Chicken luncheon meat| 3                          |
| M5          | Chicken luncheon meat| 3                          |
| M6          | Chicken luncheon meat| 3                          |
| M7          | Chicken luncheon meat| 3                          |
| M8          | Chicken luncheon meat| 3                          |
| M9          | Chicken luncheon meat| 3                          |
| M10         | Chicken luncheon meat| 3                          |
| M11         | Chicken luncheon meat| 3                          |
| M12         | Beef                 | 3                          |
| M13         | Beef                 | 3                          |
| M14         | Beef                 | 3                          |
| M15         | Beef                 | 3                          |
| M16         | Beef                 | 3                          |
| M17         | Beef                 | 3                          |
| M18         | Beef                 | 3                          |
| M19         | Beef                 | 3                          |
| M20         | Beef                 | 3                          |
| M21         | Beef                 | 3                          |

RESULTS AND DISCUSSION

Levels of lead (Pb) and cadmium (Cd) were determined in 28 canned fish (tuna and sardine) and in 21 canned meat (chicken and beef) products and the results are shown in Tables 3 and 4.
Table 3: Mean and standard deviation of lead and cadmium in canned fish.

| Sample code | fish type          | Pb mg/kg Mean ±SD | cd mg/kg Mean ±SD |
|-------------|--------------------|-------------------|-------------------|
| F1          | Tuna in oil        | 0.1619±0.00057b   | 0.1657±0.00057b   |
| F2          | Tuna in oil        | 0.0970±0.00057c   | 0.1907±0.00057b   |
| F3          | Tuna in oil        | 0.1271±0.00021b   | 0.2322±0.00686a   |
| F4          | Tuna in oil        | 0.1174±0.00035b   | 0.1170±0.00021b   |
| F5          | Tuna in oil        | 0.1579±0.00035b   | 0.1256±0.00085b   |
| F6          | Tuna in oil        | 0.1435±0.00028b   | 0.2008±0.00064a   |
| F7          | Tuna in oil        | 0.2018±0.00042a   | 0.1969±0.00028b   |
| F8          | Tuna in oil        | 0.0214±0.00049c   | 0.2169±0.00064a   |
| F9          | Tuna in oil        | 0.0283±0.00035c   | 0.1807±0.00064b   |
| F10         | Tuna in oil        | 0.1601±0.00085b   | 0.2219±0.00057a   |
| F11         | Tuna in oil        | 0.0989±0.00028c   | 0.2306±0.00071a   |
| F12         | Tuna in oil        | 0.0925±0.00028c   | 0.2068±0.00064a   |
| F13         | Tuna in oil        | 0.0337±0.00064c   | 0.1886±0.00078b   |
| F14         | Tuna in oil        | 0.1734±0.00021b   | 0.2260±0.00049a   |
| F15         | Tuna in oil        | 0.1549±0.00057b   | 0.2099±0.00028a   |
| F16         | Tuna in oil        | 0.1480±0.00120b   | 0.1797±0.00064b   |
| F17         | Tuna in oil        | 0.1530±0.00042b   | 0.1466±0.00064b   |
| F18         | Tuna in oil        | 0.1427±0.00035b   | 0.1628±0.00014b   |
| F19         | Tuna in oil        | 0.0382±0.00148c   | 0.2067±0.00057a   |
| F20         | Tuna in oil        | 0.0979±0.00014c   | 0.1829±0.00085b   |
| F21         | Tuna in oil        | 0.2294±0.00014a   | 0.2170±0.00021a   |
| F22         | Tuna in oil        | 0.0873±0.00042c   | 0.1886±0.00134b   |
| F23         | Sardine in oil     | 0.1879±0.00057b   | 0.1478±0.00028b   |
| F24         | Sardine in oil     | 0.0876±0.00042c   | 0.2016±0.00014a   |
| F25         | Sardine in oil     | 0.0557±0.00078c   | 0.1593±0.00028b   |
| F26         | Sardine in oil     | 0.1013±0.00035b   | 0.1555±0.00035b   |
| F27         | Sardine in oil     | 0.0267±0.00057c   | 0.1498±0.00014b   |
| F28         | Sardine in oil     | 0.0395±0.00007c   | 0.1575±0.00057b   |

* Values followed by different letters indicate a significant difference (p≤0.05)

Table 3 shows that all canned fish of different brands contain lead and cadmium in varying concentrations. The highest concentration of lead was 0.2294 ± 0.00014mg / kg in tuna fish sample (F21), while the lowest concentration was 0.0214 ± 0.00049mg / kg in the tuna F8 sample. On the other hand, the highest concentration of cadmium was 0.2322 ± 0.00686 mg / kg in the F3 sample and the minimum concentration was 0.1170 ± 0.00021 mg / kg in tuna F4 sample. The results of the statistical analysis showed that there were significant differences (p≤ 0.05) between the studied samples for each element.
The results showed that the lead level in 13 samples exceeded the accepted limits of the World Health Organization for lead in fish meat which was 0.123mg / kg, while the remaining values were within the acceptable limits. As for the level of cadmium in fish samples, it exceeded the accepted limits of the World Health Organization for cadmium in Fish meat (which is 0.05mg / kg) in all the tested canned tuna and sardine samples [8].

The results of the current study showed a variation in the lead levels in canned tuna fish and this is consistent with a study conducted in the Kingdom of Saudi Arabia to determine the level of lead in canned tuna fish as the lead concentration ranged between 0.03-0.51 mg / kg and an average of 0.23mg / kg which is exceeding the acceptable limit by the World Health Organization [9]. Another study conducted to determine the level of heavy metals in canned tuna fish in the local market in Tehran showed that the lead level in 54 samples from more than ten different origins was with an average of 0.053 ± 0.058mg / kg [10] which is within the permissible limits of the World Health Organization. The results of the present study also agrees with the results of another study conducted to estimate the heavy metals in canned fish from four common brands in Iran, where the cadmium level was 0.10 ± 0.04µg / g which is higher than the permissible level for human consumption [11].

Table 4: mean and standard deviation of lead and cadmium in canned fish.

| Sample code | Meat type          | Pb mg/kg Mean ±SD | Cd mg/kg Mean ±SD |
|-------------|--------------------|-------------------|-------------------|
| M1          | Chicken luncheon meat | 0.1200 ± 0.00042b | 0.1586 ± 0.00042b |
| M2          | Chicken luncheon meat | 0.0854 ± 0.00042c | 0.3078 ± 0.00035a |
| M3          | Chicken luncheon meat | 0.0521 ± 0.00028c | 0.2557 ± 0.00035a |
| M4          | Chicken luncheon meat | 0.2012 ± 0.00042a | 0.1590 ± 0.00014b |
| M5          | Chicken luncheon meat | 0.2029 ± 0.00028a | 0.1214 ± 0.00021b |
| M6          | Chicken luncheon meat | 0.1291 ± 0.00049b | 0.2115 ± 0.00028a |
| M7          | Chicken luncheon meat | 0.2454 ±0.03486a  | 0.1311 ± 0.00057b |
| M8          | Chicken luncheon meat | 0.2151 ± 0.00028a | 0.1270 ± 0.00014b |
| M9          | Chicken luncheon meat | 0.0519 ± 0.00057c | 0.2442 ± 0.00021a |
| M10         | Chicken luncheon meat | 0.0792 ± 0.00064c | 0.2309 ± 0.00028a |
| M11         | Chicken luncheon meat | 0.0766 ± 0.00064c | 0.2655 ± 0.00007a |
| M12         | Beef               | 0.0993 ± 0.00049c | 0.1333 ± 0.00035b |
| M13         | Beef               | 0.0280 ± 0.00014c | 0.2761 ± 0.00014a |
| M14         | Beef               | 0.2070 ± 0.00021a | 0.1449 ± 0.00057b |
| M15         | Beef               | 0.0876 ± 0.00085c | 0.1397 ± 0.00028b |
| M16         | Beef               | 0.0217 ± 0.00057c | 0.3091 ± 0.00014a |
| M17         | Beef               | 0.0778 ± 0.00042c | 0.3017 ± 0.00028a |
| M18         | Beef               | 0.0374 ± 0.00021c | 0.2754 ± 0.06322a |
| M19         | Beef               | 0.0852 ± 0.00064c | 0.1284 ± 0.00042b |
| M20         | Beef               | 0.0582 ± 0.00035c | 0.3088 ± 0.00035a |
| M21         | Beef               | 0.0425 ± 0.00057c | 0.3089 ± 0.00028a |

* Figures followed by vertically different letters indicate a significant difference at the probability level (p≤0.05).
Table 4 shows that all canned meat of 21 samples of different brands contain lead and cadmium in varying concentrations. The highest concentration of lead was 0.2454 ±0.03486 mg/kg in chicken luncheon meat sample M7, while the lowest was 0.0217 ± 0.00057 mg/kg in the beef M16 sample. The highest concentration of cadmium was 0.3091 ± 0.00014 mg/kg in the beef M16 sample and the minimum concentration was 0.1214 ± 0.00021 mg/kg in chicken luncheon meat sample M5. The results of the statistical analysis showed that there were significant differences (p ≤ 0.05) between the studied samples for each element. The concentration of lead in only 7 samples of canned meat exceeded the accepted limits of WHO and FAO which is 0.1 mg/kg, while the level of cadmium exceeded the internationally acceptable limit of 0.05 mg/kg in all tested canned meat samples [12].

The results showed a variation in the lead levels of the studied samples, as some of the values were within the limits accepted by the WHO and FAO, and they agreed with the results of the study of Alzuhairi et al. [13] who reported that the lead level in chicken was 0.0953 mg/kg, also with the results of the study conducted by Hamasalim and Mohammed [14] who determined the heavy elements in four samples of canned chicken luncheon produced by Jordan and France in Sulaymaniyyah markets, as the lead level was 1.19 ± 0.010, 1.02 ± 0.005, 1.00 ± 0.300, 0.52 ± 0.005µg/g, respectively, which were higher than the acceptable lead limits for poultry meat by FAO and WHO. It also agreed with the findings of Akan et al. [15] who found that the lead level in beef was 0.25mg/kg, as well as the results of the study conducted by Demirezen and Uruc [16], which showed that the lead levels in beef ranged between 0.18-0.28 mg/kg.

The results of the current study showed that the level of cadmium in most of the tested samples was 4-6 times higher than the globally allowed limit. The results of this study are consistent with the results of the study conducted by Makki [17] who investigated the microbial contamination and heavy metals in cooked poultry meat and sold in local markets of Basra Province, Iraq. Moreover, the results of the present study are consistent with what of Nasser [18] who studied the levels of heavy metals in canned meat sold in Saudi markets where the cadmium values of four samples of canned chicken meat were above the internationally allowed limit as they ranged between 0.14-0.61 mg/kg. The results of this study also agreed with what of Ei-Salam et al. [19] who found the cadmium level in beef was 1.15 ± 0.00. It is clear that the levels of cadmium reported in all the above-mentioned studies were higher than the limits allowed by the WHO. It has been reported that the pollution of heavy metals in meat products comes mainly from environmental conditions, industrial waste and mining [20].

CONCLUSION

In conclusion, the levels of lead and cadmium in almost all canned meat samples (fish, chicken, and beef) exceeded the values permitted by the WHO. In addition, the results showed that there were statistically significant differences in the levels of each element between the fish and canned meat selected samples.

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