Comparative analysis of lead and cadmium levels in various brands of canned and processed meat products in Lebanon

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Abstract

Knowledge of toxic metal concentrations in meat products is important for assessing their risk on health when consumed. Levels of such metals have neither been questioned, nor the appropriate total dietary studies (TDS) have ever been conducted in Lebanon to carry out proper risk assessments. The study reports on the levels of lead (Pb) and cadmium (Cd) in canned and processed meats sold in the north. 75 brands of canned and 33 of processed meats were purchased from local markets. Digested samples were analysed using graphite furnace atomic absorption spectroscopy (GFAAS) to determine the metals' concentrations. All samples were analysed in triplicate and included blanks and certified reference material (CRM) to validate the analysis. 46 samples (61%) of the canned showed levels of Pb ranging from 0.2 to 816.1μg/kg while 68 samples (91%) showed Cd levels ranging from 0.19 to 138.3μg/kg. For the processed, 91% of the samples revealed Pb levels ranging from 0.245 to 61.3μg/kg, while 97% tested positive for the presence of Cd in the range of 0.02 to 29.7μg/kg. In general, processed meats were found to have lower concentrations of both metals, whereas canned meats posed the greater risk. In comparison with the provisional tolerable weekly intake levels (PTWI), data showed that adults almost reached the set PTWIs for a number of samples, whereas children, have markedly exceeded such values, sometimes by 186%. Data suggests that immediate action should be taken to carry out comprehensive TDS and risk assessment studies.
Keywords: lead, cadmium, canned meat, processed meat, health hazard, microwave acid-assisted digestion, GFAAS.

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1 Introduction

The toxicity of heavy metals from food sources has been well documented over the past years in the literature [1–6]. Moreover, environmental pollution is gradually becoming an immense concern globally, and accordingly, food chain contamination is becoming ever more important in light of its role in human health and nutrition. There exist a number of environmental pollutants which constitute a potential danger to human beings [7, 8]. Sources of contamination with the rise of industries, burning of fuel, coal, and mining, all contribute to increase the body burden of such toxic elements. Even worse, everything around us from polluted air, contaminated drinking water, and accumulated toxins in foodstuffs will eventually contribute to our daily intake of specific toxins. Metals such as Pb and Cd have been shown to cause many adverse health effects in humans [9, 10]. Excess lead contamination for example, can cause serious damage to the brain, kidneys, nervous system, and red blood cells. Young children and infants are particularly vulnerable to lead poisoning. Moreover, lead has the ability to bio-accumulate in plants and animals. Its concentration is generally magnified in the food chain [11]. Cadmium, a human carcinogen [12] has a long residence time in human tissues (10-40 years), especially in the kidneys [13, 14]. For these reasons, it is of most importance to monitor the lead and cadmium content as well as other metals in dietary intakes.

Worldwide, meat is considered an important food category, being composed of mostly proteins, fat and various essential elements, is vital for growth and preservation of good health [15]. On the other hand, contamination is transferred to animals and to humans through direct exposure, polluted water and crops as well as industrial effluents and other activities [16, 17]. Other possible contamination sources of meat could arise from slaughter houses or even through transportation, processing or canning. In the developed countries (USA, Canada, EU countries, and others), numerous studies have targeted the quantification of Pb and Cd in meats and their products [17–23]. In addition to such studies, others [1–4] have utilized TDSs as suggested by health organizations, to assess the risk from consuming such products.

Due to the absence of the appropriate controls and frequent screening of meat products in Lebanon, and due to the lack of studies and research in the area, it becomes crucially important to determine the levels of such toxic elements in various meat tissues for the purpose of finding out whether the Lebanese individuals are exposed to high levels of such metals or not from consuming such products. Only one study have been made in Lebanon by Nasreddine *et al.* [3] which addressed dietary exposure to toxic metals (Pb, Cd) utilizing the TDS approach in an adult Lebanese urban population in Beirut in which toxic metals were analyzed in sample aliquots of cooked meals. The data suggested that 3.2% of the PTWI of Pb (25 µg/kg bw) have been reached, while 21.7% of the PTWI of Cd (7 µg/kg bw) have been reached. One of the major drawbacks of such study however, is the use of consumption data referring to urban population living in Beirut only which does not accommodate other urban or rural areas. Different areas in the country may prepare or use their edibles in different ways. In addition, many individuals and families are not economically and financially stable and do not have the possibility of preparing foods as suggested by the TDS approach. More important, the study did not include any of the canned and processed meats. A category of products that can be consumed without any preparation or cooking and is widely available on the go.

Accordingly, the focus of this study was first to determine the Pb and Cd levels of available canned and processed meats sold in local markets; second, to check whether such levels are above or below the maximum allowed values; third, to compare the analyzed levels with other internationally reported values; fourth, to estimate the intake of Pb and Cd when such products are consumed, and finally to raise the awareness of individuals should there be any alarming levels from exposure to such toxic metals. In our views, such study may serve as an alarm for researchers, whether in the governmental or private sectors in the area, to become engaged in this research so as to create a healthier environment.

2 Materials and methods

2.1 Reagents and glassware

Prior to any application, all plastic and glass-wares used throughout the study were washed with soap and tap water, rinsed with ddH_2O (Milli-Q system (Millipore, Numelab), and then soaked overnight in 10% nitric acid solution. Prior to usage, any item was washed three times with ddH_2O [5, 6, 9]. Acid-digested samples were stored in 50-mL polypropylene conical tubes (LaboTech, Lebanon), which were soaked in 10% nitric acid solutions, and washed with ddH_2O prior to use. Reagents and sample cups (LaboTech, Lebanon) were also soaked and washed thoroughly with ddH_2O before filling them with the samples to be analyzed. Working standards for lead and cadmium were prepared using standard solutions supplied by Romil-Pure chemistry (Standard solutions 1000ppm element reference solution). Diluted solutions of a high quality and purity 65% concentrated nitric acid were used for the sample digestion as well as for the preparation of wash solution and diluents for the Graphite Furnace Atomic Absorption Spectrometer (GFAAS) [5]. Ascorbic acid 99.99% pure and trace metal basis (purchased from Sigma-Aldrich) used as pure chemical matrix modifier for lead detection, while magnesium nitrate 99.99% pure and trace metal basis (purchased from Sigma-Aldrich) used as pure chemical matrix modifier for cadmium detection in the GFAAS. Certified Reference Material (CRM) (SRM1577C Bovine Liver NIST National Institute of Standards and Technology) were used to validate the analytical procedure utilized.

2.2 Samples and sample treatment

Canned and processed meat (cold cuts) samples were purchased from various supermarkets in North Lebanon. 75 brands of canned meat and 33 different types of processed meat were purchased and analyzed. Canned meat samples whether locally produced or imported consisted of the following groups: chicken, beef, mixed, pork, and duck. The groups have included hotdogs, luncheon meat, corned beef, pate, etc. similarly, the processed ones were divided in the following groups: turkey, pork, mixed chicken-turkey, mixed chicken-beef, mixed pork-chicken, and mixed pork-beef. Such groups have included the cold cuts or sliced mortadella, ham, salami, pepperoni, etc. For each collected sample, whether canned or processed, few grams of tissues were taken from separate subsamples of the same brand, pooled together and homogenized by cutting them into very small pieces. The homogenates were dried in a programmable oven (Venticell, W.P.Katul) at 70ºC overnight until a constant sample weight was obtained [2, 5, 6]. After drying, 0.5g of each sample was weighed and transferred to a Teflon reaction vessel specific for the Ethos 1 microwave digestion oven (Milestone Ethos 1 Labstation) followed by the addition of 7mL of purified concentrated nitric acid (65%), and 1mL of 30% concentrated hydrogen peroxide [3, 5, 6]. Similarly, and for quality control purposes, 0.5 g of the certified reference material (CRM) was also included in each batch and treated in the same manner as any other sample. After addition of the acids, the vessels were left under a fume extraction hood for at least 15 minutes to allow the formed gases to escape. The vessels were, then, sealed and placed inside the microwave oven and digested using a three-step program. During the first step, samples were heated from room temperature to 200ºC in 30min at 1000 watts. The second step consisted of maintaining the samples at 200ºC for 30 min at 1000 watts. In the final step, samples were brought to room temperature. Digested samples (~7 ml) were transferred into 25 mL volumetric flasks and were diluted with ddH_2O up to the mark prior to their transfer to 50 mL polypropylene tubes in which they were stored in the refrigerator before analysis with GFAAS.

For trace metal analysis, a Thermo-Electron M series graphite furnace atomic absorption spectrometer (GFAAS) equipped with deuterium and Zeeman background correction (Zeeman Furnace GF95Z) together with an Autosampler (FS95) was used. The sample atomization is carried out in specialized graphite tubes (Thermo Elemental Omega Platform Extended Lifetime Cuvettes). Coded hollow cathode lamps of lead and cadmium (Thermo-electron Corporation, Germany) were included in the GFAAS's carousel, where the lamp selection was done automatically based on the metal to be analyzed [5]. During all stages of Pb and Cd analysis, 99.999% pure argon gas (supplied by Chehab Industrial and Medical Gases SAL, Lebanon) was used as an internal inert gas having a flow of 300 mL/min.

2.3 Sample analysis by GFAAS

The optimized parameters for Pb and Cd were entered into the software of the GFAAS. Calibration standards were carefully prepared by simultaneous dilution of the stock solutions, starting from 1000ppm down to 10ppb (mother solution) for lead standards and 1ppb (mother solution) for cadmium standards, by using 10 fold dilutions each time, as to diminish the analytical preparation errors as much as possible. The mother solutions were used by the GFAAS's auto-sampler in order to create automatically a specified calibration curve specific for each metal. The number of calibration points was already set by the instrument and included 5 points. 0.5% nitric acid solution was used by the auto-sampler to make the needed dilutions, while 1% nitric acid solution was used to wash the auto-sampler injection tube between each dilution so as to prevent any cross-over contamination between the calibration points [5].

Aliquots of approximately 1mL of each digested sample as well as digested CRMs were placed in a 1-mL polypropylene sample cups and were arranged into the auto-sampler according to an auto-sampler guide generated automatically by the software. Standard mother solution, diluents, as well as the matrix modifiers were placed in 20 mL polypropylene reagent cups, and loaded into the auto-sampler according to the same auto-sampler guide [5].

The total analysis, starting from calibration curve preparation ending up with the sample analysis was programmed to be carried out without any human interference thus decreasing contamination sources [5]. With the purpose of eliminating any possible contamination, the auto-sampler washes itself after each run with 0.1% nitric acid solution.

The auto-sampler can perform up to sixty samples injections in addition to all the necessary dilutions and preparations, in one run, thus ensuring high quality control of analysis. On the other hand, all specimens were run in batches with digested blanks and digested CRMs. Digestion blanks were used to test for the presence of any possible contamination throughout the whole procedure [6]. Furthermore, all samples were analyzed in triplicates, where a mean value is calculated. For further quality control, the instrument was programmed to periodically re-measure sample blanks and standards from the calibration curve every 10 samples to check for any instrumental variations during the analysis, thus ensuring fidelity and consistency of the data. Moreover, and for investigating the recovery of the whole procedure, every batch included a sample of certified reference material so as to ensure that the method used was accurate and that the produced results are genuine. In this case, all our CRM samples had recovery values that ranged within the acceptable analytical range of 80–120%.

3 Results and discussion

Due to highly important reasons discussed earlier, and since such products were never tested before in this country, and because the only TDS [3] study done does not include such products, it becomes a necessity to carry out this study. The analyzed samples in this study, their place of origin, and their mean concentrations of lead and cadmium are summarized in tables 1 and 2.

The levels of Pb and Cd whether in canned or processed meat products extended over a wide range of concentrations (tables 1 and 2). This strongly suggested that Pb and Cd contamination was not only due to a constant factor such as processing and/or canning, but rather to many other factors which may include type of meat, its origin, and diet of the corresponding animal during the bringing up process. In table 1, 46 samples (61%) of the canned meat showed levels of Pb ranging from 0.2 to 816.1µg/kg, whereas 68 samples (91%) showed Cd levels ranging from 0.19 to 138.3µg/kg.

Table 1: Lead and cadmium concentrations analyzed in canned meat brands. In the main text, sample brands are referred to by using their sample codes. Values are reported as mean concentrations in µg/kg based on dry weight basis.

Sample code	Brand Name	Place of Origin	Pb (µg/kg)	Cd (µg/kg)
B1	Maxim's Corned Beef	Brazil	nd	nd
B2	Food Love	Brazil	nd	75.76
B3	Zwan Beef	Holland	nd	38.87
B4	Zwan Beef Hot & Spicy	Holland	nd	20.35
B5	Bordon	Brazil	nd	nd
B6	Del Monte Beef Luncheon Meat	Jordan	nd	21.86
B7	Target Corned Beef	Holland	nd	2.41
B8	Niers Saussages	Holland	nd	0.65
B9	Target Corned Beef Low Fat	Holland	nd	0.82
B10	Al Maraai Jordonia	Jordan	nd	65.75
B11	Maxim's Frankfurter Beef	Brazil	0.3	nd
B12	Sara Luncheon Meat	Brazil	1.2	4.15
B13	Maxim's Corned Beef Black	Brazil	2.7	0.43
B14	Zwan Beef Hot Dog In Glass	Holland	3.4	3.8
B15	Groot		3.8	6.87
B16	Maxim's Beef Pate	Brazil	4.2	4.13
B17	Poppenburger frankfurters Beef	Germany	7.7	3.48
B18	Deli Beef	Jordan	9.4	9.79
B19	Bocklunder Beef Bockwurst	Germany	13.2	0.19
B20	Maxim's Frankfurter	Brazil	15.3	4.71
B21	Maxim's Beef Luncheon Meat	Brazil	17.7	1.96
B22	Niers Beef	Holland	25.5	28.21
B23	Poppenburger USA Pure Beef	Germany	23.9	1.2
B24	Food Love Hot Dog	Brazil	55.3	89.27
B25	Maxim's Beef Hot Dog	Brazil	60.4	7.94
P1	Niers Bockwurst	Holland	nd	nd
P2	Poppenburger USA Style	Germany	nd	nd
P3	Tulipe Pork Hot Dog	Denmark	nd	19.66
P4	Tulipe Liver Pate	Denmark	nd	74.53
P5	Poppenburger USA	Germany	nd	7.27
P6	Maxim's Frankfurters	Germany	1.2	0.41
P7	TEDDY	China	2	9.89
P8	La Piarra Frankfurt	Spain	2.2	5.78
P9	PoppenburgerBockwurst (Green)	Germany	6.4	1.8
P10	La Piara Pate La Pimenta	Spain	9.6	3.52
P11	Poppenburger Bockwurst (Red)	Germany	17.5	2.93
P12	Maling Scof Pork	China	28	5.83
P13	Maxim's Pork Hot Dog	Brazil	76.5	138.3
P14	Epicure Pate	Belgium	413.9	30.71
M1	Maxim's Duck Pate	Brazil	nd	4.98
M2	Al Mouna Beef Hot Dog	Holland	nd	9.21
M3	Plumrose Hot dogD	Germany	nd	8.59
M4	Zwan Beef + Olives Luncheon Meat	Holland	0.2	23.14
M5	Zwan Beef + Olives Luncheon Meat Mortadella	Holland	3.2	5.29
M6	Everyday Hot Dog		6.3	26.68
M7	Zwan Turkey + Herbs	Holland	8.8	21.66
M8	Niers Beef Hot Dog	Holland	18.4	10.4
M9	Al Mouna Beef Luncheon Meat	Holland	24	32.73
M10	Tulipe Beef + Chicken Hot Dog	Denmark	24.9	23.06
M11	Al Taghziah Beef	Lebanon	30.3	14.54
M12	Turkey Saussages		36.7	4.77
Ch1	Zwan Chicken Tandoori	Holland	nd	4.77
Ch2	Zwan Chicken + Paprika	Holland	nd	4.2
Ch3	Del Monte Chicken Luncheon Meat	Jordan	nd	18.9

Table 1: (Continued).

Ch4	Zwan Chicken + olives Luncheon Meat	Holland	nd	11.15
Ch5	Tanmia Chicken Luncheon Meat	Lebanon	nd	9.06
Ch6	Zwan Hot dog	Holland	nd	55.81
Ch7	Al Taghziah chicken Luncheon Meat Mortadella	Lebanon	nd	32.76
Ch8	Niers Chicken	Holland	nd	4.19
Ch9	Zwan Chicken Hot Dog In Glass	Holland	1.4	2.53
Ch10	Zwan Chicken Hot Dog	Holland	3.6	1.75
Ch11	Maxim's Chicken Luncheon Meat	Brazil	8.1	2.47
Ch12	Al Mouna Chicken	Holland	11.5	9.95
Ch13	Tulipe Chicken Luncheon Meat	Denmark	11.6	0.69
Ch14	Target Chicken Luncheon Meat	Holland	12.1	nd
Ch15	Maxim's Chicken Luncheon Meat	Brazil	19.1	1.6
Ch16	Maxim's Chicken Hot Dog	Brazil	25.2	34.31
Ch17	Maxim's Chicken Pate	Brazil	26.5	2.66
Ch18	Tulipe Chicken Hot Dog	Denmark	38.2	3.3
Ch19	Golden Fields	England	46.8	38.78
Ch20	Zwan Chicken	Holland	47.7	4.24
Ch21	Al Taghziah Chicken Luncheon meat	Lebanon	816.1	36.21
Ch22	Zwan Chicken Hot & Spicy	Holland	nd	4.91
D1	Pate au Fois Gras	Lebanon	nd	5.24
D2	Pate au Fois Gras in Glass	Lebanon	nd	nd

B= beef, P= pork, M= mixed, Ch= chicken, D= duck, nd= nondetectable.

For the Processed (table 2), 91% revealed Pb concentrations ranging from 0.245 to 61.3µg/kg, while 97% tested positive for the presence of Cd and ranged from 0.02 to 29.7µg/kg.

It was noted that concentrations of both metals were generally higher in canned meats (table 1) as opposed to the processed ones (table 2). This may be explained by the fact that leaching of both metals can occur from the can itself and into the product [24]. Moreover, and within each category, most samples showed slightly higher Pb levels than for Cd. This may be explained due to the fact that Pb is more abundant than Cd thus leading to its role in increased accumulation and contamination. In general and when considering the general public, the data suggests that the safest products to consume are those containing non-detectable concentrations of both metals. Such products may include B1, 5, and 11, P1 and 2, and D2 (table 1).

It is well known in Lebanon that no regulations exist whatsoever to control the allowed amounts of toxic metals in food and their products. Therefore, it is necessary to use a certain guideline to figure out where we stand. According to the EU directive 466/2001 [1], which regulates the amounts of Pb and Cd in meat and their products, have set the maximum allowed levels (MAL) of both metals to be 100 and 50 µg/kg, respectively. As for this study, it can be observed that various sample brands have markedly exceeded such levels where P14 (413µg/kg) and Ch21 (816.1µg/kg) have exceeded the MAL of Pb. As for the MAL of Cd, B2 (75.76µg/kg), B10 (65.75µg/kg), B24 (89.27µg/kg), P4 (74.53µg/kg), P13 (138.3µg/kg), and Ch6 (55.81µg/kg) have all exceeded its allowed value (table 1).

In an attempt to compare our results with ones published internationally, it was very difficult to find published data that included canned meat products similar to the ones used in this study. From the 108 total sample brands studied

Table 2: Lead and cadmium concentrations in processed meat brands. In the main text, sample brands are referred to by using their sample codes. Values are reported as mean concentrations in µg/kg based on dry weight basis.

Sample code	Brand Name	Place of Origin	Pb (µg/kg)	Cd (µg/kg)
T1	Hohenrainer Turkey Grill Roast	Germany	nd	4.75
T2	Wawo Chicken Turkey		10.8	1.53
T3	Hispania Deli Fume Turkey	Spain	26.61	1.18
T4	Hohenrainer Turkey Mortadella + Paprika	Germany	14.6	4.64
T5	La Piara Turkey	Spain	25	2.54
T6	Hohenrainer Mortadella Classic	Germany	3.47	2.08
T7	Voila Turkey Fume Turkey	Spain	20.84	7.17
P1	Buffet Premium	Spain	nd	0.80
P2	El Trineo Salami Pork		31.22	nd
P3	Le 1er Choix(DD) Le Vrai Jambon Pork	UE	39.24	3.35
P4	Voila Pork	Spain	49.7	0.75
P5	Jambino Jambon	Bellgium	2.96	nd
P6	El Trineo Salami Poivra Pork		27.87	0.41
P7	La Piara + Olives Pork	Spain	43.9	1.36
P8	Wenbo Peperoni	Denmark	1.11	3.06
P9	Monells Mortadella Pork		38.08	2.89
P10	Leoncini Mortadella Pork	Italy	11.6	0.25
P11	Negroni Salami	Italy	1.99	2.60
P12	Citterio Mortadella Pork		14.68	0.75
P13	Carsodo Salami + Pepper Pork	Girona	4.91	0.49
P14	Continental Jambon Pork	Bellgium	10.98	5.10
P15	Divina Mortadella Pork	Italy	24.6	6.36
P16	Jambino Jambon Fume	Bellgium	0.245	0.56
P17	Carsodo Salami	Girona	1.04	0.38
P18	Negroni Pork	Italy	61.3	0.02
(C+T)1	La Piara Dinde	Spain	nd	0.27
(C+T)2	La Piara Halal Turkey	Spain	7.77	4.97
(C+T)3	La Piara Mortadella Chicken	Spain	10.88	2.64
(C+T)4	La Piara Halal Chicken	Spain	8.6	3.40
(B+C)1	La Piara Beef + olives + pepper (Beef + chicken)	Spain	28.48	3.33
(B+C)2	La Piara Halal Beef (Beef + chicken)	Spain	17.23	29.70
P+B	Leoncini Mortadella Beef + Pork	Italy	40.4	4.63
P+C	Tello Mortadella + olives (Pork + Chicken)	Spain	54.36	3.75

T= turkey, P= pork, C+T= chicken + turkey, B+C= beef + chicken, P+B= pork + beef, P+C= pork + chicken, nd= non-detectable.

in this work, we were able to compare only eight. Four of the processed meats (table 2) namely P3, 5, 14, and 16, which are ham were compared to six published studies between 1983 and 2002. Levels of Pb reported for P3 and 5 were comparable to Cervera [25], and Becerra *et al.* [26] respectively.

Whereas for Cd, P3, 14, and 16 were comparable to Dabeka and McKenzie [21], Cervera [25], and Karavoltsos *et al.* [22], respectively. For the rest of the ham samples, they were well below those reported by Catalá *et al.* [27], Cattaneo and Balzaretti [28], and Brito *et al.* [29].

Regarding the corned beef samples, four of the canned meats namely B1, 7, 9, and 13 were compared to Meah [30] and Onianwa *et al.* [23]. Our values in all four samples were much lower than those previously reported for both metals. In either case, neither the canned nor the processed meat brands discussed here (processed: P3, 5, 14, and 16, canned: B1, 7, 9, and 13) have exceeded the MALs of both metals. However, the concern arises from those that did exceed the allowed levels which were discussed earlier.

According to the TDS study made by Nasreddine *et al.* [3], the average weekly intake of Pb has reached 3.2% of the PTWI (25µg/kg bw), whereas the average weekly intake of Cd has reached 21.7% of its standard value (7µg/kg bw). Needless to mention, that such study did not account for any canned or processed meats nor can it be considered as a comprehensive total dietary study. However, it can serve as a guideline to calculate the additional intake that would be contributed from consuming canned or processed meats.

Lebanon is one of the countries that have recently been engaged in the process of performing Total Dietary Studies (TDS) as a reply to the EFSA/FAO/WHO questionnaire on national TDS approach [31], and yet still at the beginning in applying effectively and appropriately such studies. According to the European Environment and Health Information system, most European countries had an adult Pb intake levels ranging between 10-30% of the lead's PTWI and sometimes higher [32]. Given that Lebanon is a developing country in which no environmental or health regulations exist, nor does it have any food safety monitoring programs and regulations but yet its Pb intake is surprisingly much lower (3.2%) than that of the European countries (10–30%). It is not clear to why this great difference exists between the local TDS versus the EU TDS but this might be explained due to non-comprehensive nature of the TDS carried in Lebanon. In any case, the Lebanese TDS must be used since the study is area specific.

Knowing that the weekly intake of Pb reached 3.2% of its PTWI (25µg/kg), the remaining allowable intake (24.2 µg/kg) will not be reached by a 60-kg adult when consuming one can (400g) or even two cans per week of any of the samples, which is still a reasonable amount to consume. However, if a 14-kg child consumes the same amounts, and without taking into account any TDS studies, the child can reach 93 and 186% of the PTWI when 1 or 2 cans of Ch21 or P14 (table 1) are consumed, respectively. This suggests that with a more comprehensive TDS, the intake level might increase thus making the matter worse for adults and even devastating for children.

Regarding cadmium, its intake through the food chain in the Lebanese TDS was found to be 21.7% of the PTWI (7µg/kg bw), which is also surprisingly lower than that of Europe (40-60%) [32]. In that case, a 60-kg adult should have an additional allowable intake of Pb of 5.48µg/kg in order to reach 100% of the PTWI. None of the samples analyzed were found to cause any risk when consumed. However, and similarly for children, consuming 800g of B24 or P13 per week can place them at risk. In both cases, whether for Pb or Cd, intake levels must be regulated specifically for children in order to minimize exceeding the allowable levels.

Overall, the results of this study have suggested that is it safer to consume processed meats in comparison to canned ones since the processed products contained lower levels of both toxic metals. In addition, individuals should become aware of such results and should have the right to choose safer products so as to minimize exposure risk to such toxic elements. Consumption of products low in lead and cadmium whether in the canned or processed category do exist and can greatly minimize such exposures. Children were found to be most vulnerable and affected the most and therefore should minimize the consumption of such products. Whether being an adult or a child, the intake amount should be minimized as a basic rule so as to minimize the intake of such toxic metals since their presence has been confirmed. Last but not least, there is an urgent need to carry out comprehensive TDS studies specific for Lebanon only then, one can state with higher accuracy which products are safe and which are not.

4 Conclusion

The concentrations of lead and cadmium analyzed in this work revealed that two canned samples, (P14 and Ch21) have exceeded the MAL set for Pb by the European directive, whereas six canned samples (B2, 10, and 24, P4 and 13, and Ch6) have exceeded the MAL for Cd. This suggests that it is safer to consume processed meats as opposed to canned ones since the former showed lower concentrations of both metals and none have exceeded the MALs. Four of the total canned samples studied (P14, Ch21, B24, and P13) were found to contribute the highest intake when consumed by adults. Children were found to be markedly affected by such products where PTWIs were exceeded in their case.

Overall, this study suggests that the consumption of such products should be strictly controlled and minimized, especially for children. In light of this, researchers in the area as well as national health organizations should really engage in constant monitoring and evaluation of toxic metal levels in foodstuffs so as to establish national allowable values for the population and to strictly control any imported or even locally produced products since levels of toxic metals may change from time to time due to many factors.

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