Assessment of Health Risks due to Exposure to Cadmium and Lead of the Population of Daloa through the Consumption of *Choukouya*

AKESSE Djamatchè Paul Valéry[1], DALOGO Kacou Alain Paterne[2], KOFFI Akissi Chantal[3], MAMADOU Koné[4]

[1, 3]Jean Lorougnon Guédé University of Daloa, P.O Box 150 Daloa, (+225) 32767572
djamatche[at]yahoo.fr; koffichantal03[at]hotmail.com

[2]Central Laboratory for Food Hygiene and Agro-Industry, 04 P.O Box 612 Abidjan 04, (+225) 20225843
pak_dalogo[at]yahoo.fr

[4]Nangui Abrogoua University of Abidjan, 02 P.O Box 801 Abidjan 02, (+225) 22510070,
kismadou[at]gmail.com

Abstract: ***The present study aims to assess the health risks due to Cd and Pb incurred in the consumption of Choukouya by the population of Daloa. To do this, 30 samples of mutton, beef and chicken (fresh and cooked) taken were analyzed with an atomic absorption spectrophotometer by the graphite oven method. It emerges from the analysis that the meat species used in Choukouya are effectively contaminated by Cd and Pb at variable rates with an exceeding of the edibility criteria at the level of Pb. The accumulation of Pb is preferential than that of Cd in different species of meat. Mutton cooked with a Pb content range of between 308.4 µg/kg and 414 µg/kg is the most contaminated Choukouya meat. furthermore, the risk characterization showed that this meat used under Choukouya conditions would present dangers for consumers with a QD>1 for Pb for all age groups (QD=2,3➔Adolescent; QD=1,55➔Young; QD=1,38➔Adult). We also note that a QD>1 for beef (QD=1, 11) and chicken (QD=1,43) only in the "Adolescent" age group. Furthermore, we can consider that there is no danger of the appearance of toxic effects linked to Cd with a QD<1 for all age groups and whatever the animal species. The resulting ERI (Pb) is lower than the probabilistic limit set by the WHO (10^{-5}mg^{2}.kg^{-2})..***

Keywords: *Choukouya*; Heavy Metals, Danger Quotient, Excess Individual Risk

1. Introduction

Choukouya is a dish made from beef or other types of meat cooked in the open air over a charcoal, wood or grill fire. It is sold practically on every street corner in towns in the Ivory Coast and some countries in West Africa. This dish commonly known as *Barbecue* in Europe, *Dibi* in Senegal, *Tchatchanga* in Benin and *Choukouya* in Côte d'Ivoire is highly prized by city populations [1-4]. However, the meat of animals used in *Choukouya* is subject to various forms of microbiological and chemical contamination, including that by heavy metals [5-7]. The way animals are fed before slaughter, the cooking method and the packaging of the different species of meat give rise to worrying concerns about the health risks linked to metal pollution. In addition, some work has shown that meat and offal from beef, mutton and poultry have the capacity to absorb certain harmful chemicals such as heavy metals [8-12]. However, these "silent" toxicants such as Cd and Pb are involved in the physio-pathological processes of human beings [13-17]. Thus, by virtue of their toxicity with non-threshold effects, their presence in food and eating habits, these chemical pollutants will pose a public health problem. The assessment of health risks, which is therefore necessary, will make it possible, on the one hand, to estimate exposure to a pollutant that can cause effects to occur in a human body. And on the other hand, it will make it possible to characterize and then prevent the risks still associated with this contamination. It is in this context that this research work on the assessment of the health risks due to exposure to Cd and Pb of the population of Daloa is situated through the consumption of *Choukouya*. The research objective is to assess the health risks due to Pb and Cd in the consumption of *Choukouya*. It will be specifically:

- Determine the sanitary framework linked to the cooking method of *Choukouya*;
- Determine the level of concentration of Cd and Pb in the different species of fresh and cooked meat;
- Estimate the dietary exposure to Cd and Pb in the consumption of *Choukouya*;
- Characterize the risks incurred.

2. Materials and Methods

2.1. Study areas

The study area is located in the city of Daloa in its urban part. This city is located in the central western part of the Ivory Coast about 383 km from Abidjan. It is the capital of the department of Haut-Sassandra region. It is the 3rd most populous city in the Ivory Coast after Abidjan and Bouaké. It has more than 261,789 inhabitants [18].

2.2. Study matrices

The matrices used in this study are composed of three species of meat used in the preparation of *Choukouya*. Thus, we have the fresh and cooked meat of Mutton, Beef and

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Poultry (Chicken). The choice of study animals takes into account the near permanence of their meat on sales sites and their preference by consumers.

2.3 Analysis material

Prior to laboratory analysis, survey and sampling was carried out from vendors and consumers. Thus, survey and identification sheets for the samples taken and a GPS for locating sampling sites were used. Food pouches were used for sample packaging. The apparatus used in the laboratory for the analysis of different metals is a VARIAN SPECTRA A110 brand atomic absorption spectrophotometer.

2.4 Methodological approach

The approach consisted on the one hand in quantifying the state of contamination of the different types of meat used in *Choukouya*, and on the other hand in assessing the risks incurred by the populations due to the consumption of these foods. Thus, we took and analyzed samples of fresh and cooked mutton, beef and chicken, then determined a daily mass ration common to the three types of meat for the assessment of exposure in order to characterize the risks incurred.

2.5 Food survey

A food survey was carried out in the town of Daloa at certain *Choukouya* sales sites. At the end of this, we counted a total of 51 sites (**Figure 1**). It identified the animal species commonly used in the preparation of *Choukouya* and the most consumed. This survey made it possible to determine the habits and frequency of consumption of different animal species in *Choukouya* and the environmental and health framework of the sales sites.

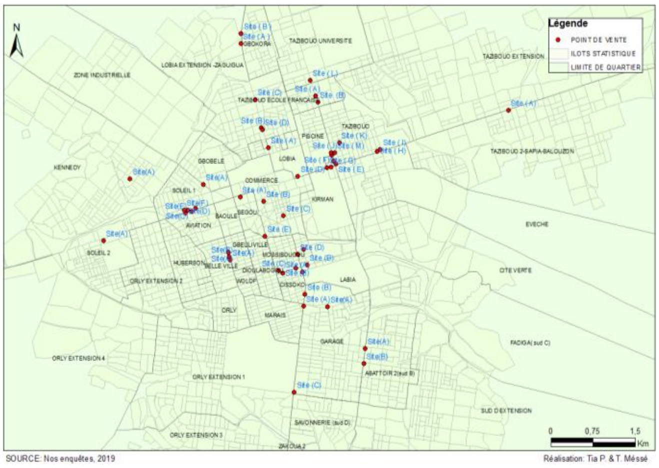


Figure 1: *Choukouya* sampling sites in some points of sale in Daloa

2.6 Sampling, mineralization and analysis methods

2.6.1 Sampling

Sampling of the different species of meat was done manually from vendors under the same purchasing conditions as consumers. For the same species of meat, two batches of meat were established during the sampling: namely one batch of fresh meat and one batch of cooked meat for each animal species and per sales site. Each species of fresh meat in the study is cut and placed directly in a plastic food bag for the laboratory. While the species of cooked meat are seasoned by the seller. These are put in cement wrapping paper according to the usual mode of service of the sellers. A total of 30 meat samples (fresh and cooked) were taken. These will undergo acidic mineralization in the laboratory before being analyzed with an atomic absorption spectrophotometer.

2.6.2. Chemical analysis

2.6.2.1. Acid mineralization

Before use, all equipment (glassware, bottles) likely to come into contact with the samples is carefully cleaned by soaking at room temperature in a dilute 10% nitric acid solution, followed by rinsing with demineralized water and drying in an oven. Thus, the various samples of fresh and cooked meats were mineralized by acid attack after calcination at 525 ° C in a muffle furnace according to the protocol recommended by the center of expertise in environmental analysis of Quebec [19]. Indeed, after having dried the samples of the different animal species in an oven for 48 hours in silica crucibles, they are calcined until a whitish cinder is obtained. A test portion of 0,5 g of the ash obtained per sample is dissolved in 2 mL of HNO_3in a beaker slightly heated in a water bath under a hood. The solution obtained is filtered using a wathman filter paper with a porosity of 0,45 µm in a 50 mL volumetric flask. Then the filtrate is made up with distilled water to the mark (previously homogenized).

2.6.2.2. Determination of heavy metals

After the mineralization step, all the samples are transferred to the Central Laboratory for Food Hygiene and Agro-Industry for the determination of Cd and Pb. The determination of these metals was carried out according to a protocol standardized in the detection of these by atomic absorption spectrophotometer (AAS) according to the graphite furnace method.

2.7 Methods of assessing health risks by ingestion

The health risk assessment was carried out using a four-step approach [20];[21] :

2.7.1. Identification of potential dangers

It is the identification of biological, chemical and physical agents present in food capable of causing harmful effects on human health [17]. This step will allow us to detect the presence of Cd and Pb in the different meats of *Choukouya*.

2.7.2. Hazard characterization

This is the qualitative or quantitative assessment of the harmful effects on health including, if possible, the assessment of the dose-response in humans [17]. Cd and Pb are carcinogenic toxicants with a non-threshold effect and are non-essential in the human body. Therefore, their qualitative or quantitative presence could lead to the occurrence of certain pathologies. This step will allow us to compare the Cd and Pb concentrations in the different meats with those of Maximum Reference Concentrations (MRC) set by international bodies. This will reflect the dose-effect relationship which characterizes the dangers due to the presence of these toxicants at the concentration threshold.

2.7.3. Exposure assessment

This is the qualitative or quantitative assessment of the probability of ingestion of food hazards by consumers, taking into account, where appropriate, other routes of exposure to the risk [17]. This step made it possible to know the sanitary framework and the cooking method of *Choukouya* (qualitative assessment) on the one hand. Then, it also made it possible to estimate exposure to Cd and Pb in the consumption of *Choukouya* (quantitative evaluation). The exposure estimate is based on the following different mathematical formulas:

Theoretical Maximum Daily Intake (TMDI): Theoretical maximum quantity of a given active or harmful substance that an individual is likely to ingest daily throughout his life (in µg of active substance/kg of body weight/day). This is a theoretical maximalist estimate of population exposure. It can then be said to be safe, but it does not reflect a real exposure of the latter. It will allow us to verify that the consumer is not ingesting a quantity of harmful contaminants greater or less than the Tolerable Daily Intake (**TDI**) : $TMDI = \sum [Metal]_{reference} \times Q_{meat}$

TMDI : in µg/pers/day ; $\mathbf{[Metal]_{reference}}$: MRC of Heavy $Metal_{(i)}$ in the food in µg/g ; $\mathbf{Q_{meat}}$: Average daily amount of meat consumed per person in g

	MRC of Heavy Metal in µg/kg	
Type of meat	Cd	Pb
Mutton, Beef, Chicken	50	100

Estimated Daily Intake (EDI): This intake represents the load of heavy metals ingested via the quantity Q_{meat} of *Choukouya* consumed by an individual on a regular and daily basis. When determining the EDI, we instead used the levels of heavy metals found in cooked meats instead of the MRC set by international institutions.

$$EDI = \sum [Metal]_{estimated} \times Q_{meat}$$

EDI: in µg/pers/day; $\mathbf{[Metal]_{estimated}}$: Average concentration of Heavy $Metal_{(i)}$ in cooked meat in µg/g ; $\mathbf{Q_{meat}}$: Average daily amount of meat consumed per person in g.

Theoretical and Real Daily Exposure Doses (DED): The theoretical and actual daily exposure dose are obtained by the following formulas: $DED_{theo} = \frac{TMDI}{bw}$ et $DED_{real} = \frac{EDI}{bw}$

DED in µg/kg.bw/days**; TMDI , EDI** : in µg/pers/day ; bw : Average body weight of exposed individuals in kg.

2.7.4. Risk characterization

Qualitative or quantitative estimation, with the accompanying uncertainties, of the probability of occurrence of risks and of the severity of harmful effects on health for a given population.

This characterization is based on the following different mathematical formulas:

Danger Quotient (DQ): $DQ_{theo} = \frac{DED_{theo}}{TDI}$ and $DQ_{real} = \frac{DED_{real}}{TDI}$

TDI : Tolerable Daily Intake

The value of the DQ allows us to conclude only on the potential appearance of effects or not and on their importance ([22] **Persoons, 2011**) as follows:

- As long as "**DQ<1**": the exposure of populations does not pose theoretically a health problem.
- But if "**DQ>1**": this means that toxic effects are likely to occur among the exposed population.
- **Excess of Individual Risk (EIR)**: This is the probability of a danger occurring, during an individual's entire life, linked to exposure to a carcinogenic agent [23].

$EIR = DED \times \frac{T}{T_P} \times TDI \times F$ with: **EIR** : $mg^2.kg^{-2}$; **T** : duration of exposure (years); $\mathbf{T_p}$: weighting time (entire life, in years); **DED** : in mg/kg.bw/day ; **TDI** : in (mg/kg.bw/day) ; **F** : frequency of exposure in day/year (number of days of exposure/365 days)

2.8 Statistical method of data processing

The statistical analysis of the data, the plots of graphs are carried out using the *Statistica 6* software and the *Excel 2016* spreadsheet. A logarithmic transformation (log ([ETM] +1)) was carried out in order to reduce the heterogeneity of the variance observed in the concentrations of the different samples and to better represent them graphically. In addition, a Fisher Snedecor F test made it possible to compare the difference in concentration means between the different samples from the different sampling sites. The F-test is a fairly convenient statistical method for comparing multiple means simultaneously. The observation of the value of the F homogeneity test is set at the threshold of 5% ($F_{0,05}$). So if the calculated (observed) test F is greater than $F_{0,05}$, we say that the differences between the means are significant.

3. Results

3.1 Description of the study population

The size of the surveyed population amounted to 512 people with 79,49% men and 20,51% women. The consumers surveyed are almost sedentary as the survey revealed that 76,56% of them have lived in Daloa for more than 5 years. The compilation of socio-demographic data made it possible to divide the study population into three age groups with the following different average body masses :

- Age range [11-20 years] : (*Teenager*) average body mass equal to 46,53 kg
- Age range [21-40 years]: (*Young*) average body mass equal to 69,17 kg
- Age range [41-70 years]: (*Adult*) average body mass equal to 77,53 kg

3.2 Health framework of the activity

All the *Choukouya* sales sites in the city of Daloa are located on the sidewalks of streets with high human and car traffic. A small artisanal shed covered with old metal sheets serves as the premises. A clay oven covered with a perforated black metal tray is set up for braising meat. Cooked meat is usually served to customers in cement wrapping paper. Thus, across all sites visited 92,16% of vendors use cement paper as wrapping to serve cooked meat or its packaging. Only 7,84% of sites use meal trays across the city (**Figure 2**).

Figure 2: Types of conditioning of *Choukouya* meat

3.3. *Choukouya* consumption habits

3.3.1. Frequency of consumption

The results of the food survey show that individuals who consume at least 2 to 3 times *Choukouya* have a high percentage which is 28,13%(**Figure 3**). This data was used to calculate the frequency F of consumption which was extrapolated over one year with F = 0, 0986.

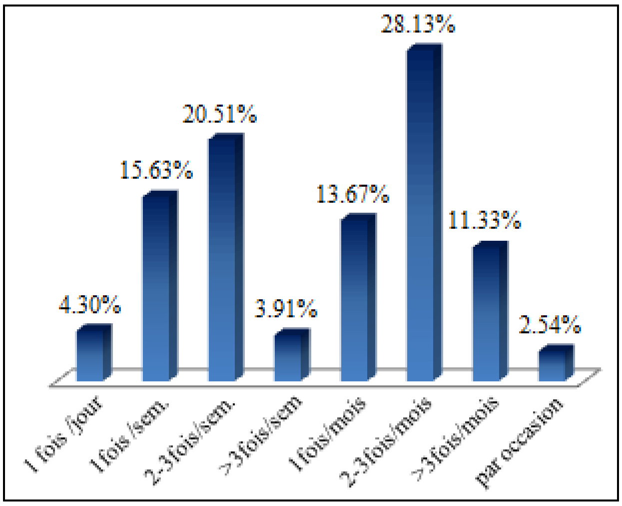


Figure 3 : Fréquence de consommation du « choukouya »

3.3.2. Preference consumption of animal species

The consumer food survey showed that the order of preferential consumption of the meats used in *Choukouya* is as follows: Chicken is the most consumed (51,37%), followed by mutton (24,80%) and in last place of beef (23,83%). The average mass amount of the daily food ration per consumer was determined to be 438,77g.

3.4. State of metallic contamination of the *Choukouya* meat studied

3.4.1. Heavy metal concentration level of the meat species used

Figures 4, 5 and **6** show through the histograms, the variation of the concentration levels of Cd and Pb according to the different sites of sale of *Choukouya*.

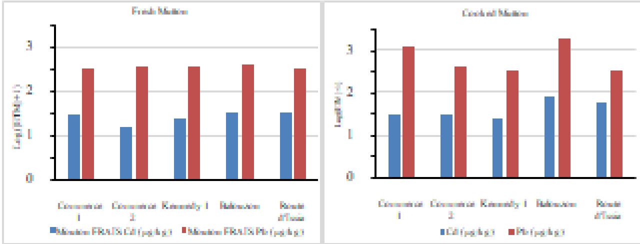


Figure 4: Variation in the level of metal contamination of mutton

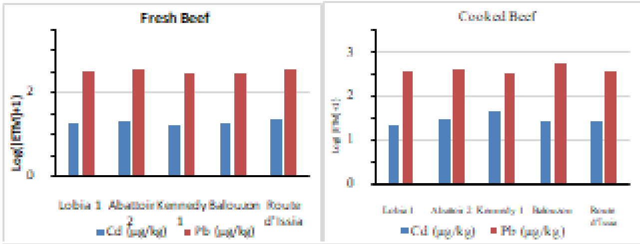


Figure 5: Variation in the level of metal contamination of beef

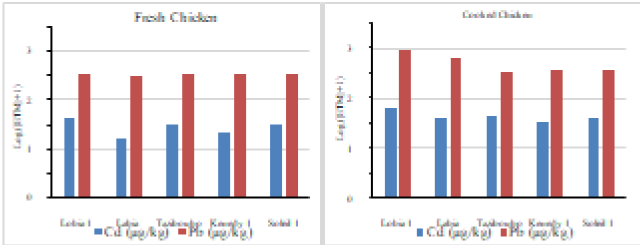
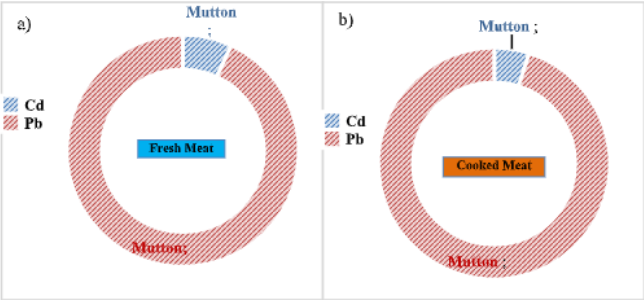


Figure 6: Variation in the level of metal contamination of chicken

The results show that the desired Cd and Pb were detected in all the samples analyzed. Analysis of the histograms shows that the Pb contents are very high than that of Cd, regardless of the type of meat (fresh or cooked) and for all sampling sites. In addition, the Fisher F test of homogeneity of variances applied to the metal concentrations of the different species of fresh and cooked meat is greater than the 5% threshold shows that the differences observed between the concentration levels of the different metals and their distributions in the mutton, beef and chicken are significant. This allows us to say that the accumulation of Cd and Pb is influenced by the meats (fresh and cooked) of different animal species.

3.4.2. Ranges and preferential rate of accumulation of heavy metals studied

The prime rate of metal accumulation in different species is in the range of 92% to 95% for Pb, while it is lower for Cd in the range of 4% to 8% (**Figure 7**). These results show that cooked meats have higher concentration ranges than fresh meats. This shows that the meat is all the more contaminated than when it is cooked under *Choukouya* conditions.



a) b)

Figure 7: Percentage of accumulation of Cd and Pb in *(a)* fresh and *(b)* cooked meats

3.4.3. Comparison of average heavy metal contents to the standard

In order to assess the degree of contamination of the meat of different animal species and to characterize the danger, we compared the average concentrations of the different Heavy metals studied present in the different matrices with their standard (**Figure 8**).

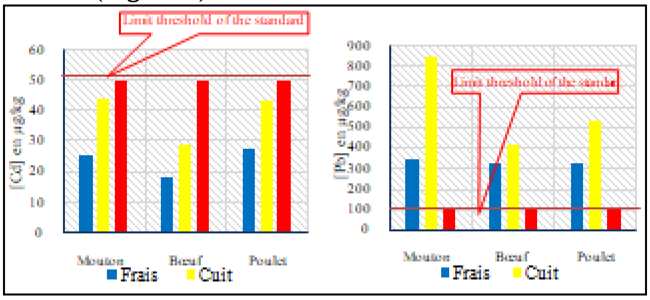


Figure 8: Average measured contents and WHO standards for Cd and Pb

The histograms in **Figure 8** show according to Regulation N° 1881/2006 of the Commission of the European Communities of December 19, 2006 (fixing the maximum levels for certain contaminants in foodstuffs), that only the average levels in Pb in fresh or cooked mutton, beef and chicken meats are above the standard set at 100 µg/kg [24]. For Cd, the average levels observed are lower than the WHO standard. This observation allows us to highlight the order of metallic accumulation and preferential affinity of the different species of meat to the metals studied. We have:

- **Order of metallic accumulation**: [Pb]>[Cd] for all meats (fresh or cooked).
- **Order of affinity for Heavy metals**: Mutton> Chicken> Beef Whatever the toxic Cd or Pb.

3.5. Assessment of health risks associated with exposure to heavy metals via food

3.5.1. Estimation of theoretical dietary exposure

The values obtained for each animal species are listed in **Table II**.

Table II : Values of theoretical daily intakes and doses in Cd and Pb of meat species

Animal species	Heavy metals	MRC (µg/kg)	TMDI(µg/pers/day)	$DED_{(théorique)}$ (µg/kg.bw/day)		
				Teenager	*Young*	*Adult*
Mutton, Beef, Chicken	Cd	50	21,94	0,47	0,32	0,28
	Pb	100	43,88	0,94	0,63	0,57

Table II shows that the calculated values of the TMDI and the Theoretical DED (DED_{theo}) for Pb are twice as high as those calculated for Cd, regardless of the animal species. In addition, the (theoretical) DED_{theo} values of the *Teenager* age group are all higher than those of the other age groups (*Young* and *Adult*) for the two pollutants and regardless of the type of meat. We observe this following order: $DED_{theo\,[Teen]}>DED_{theo\,[Young]}>DED_{theo\,[Adult]}$. This result shows that adolescents probably receive a greater pollution load than young people and adults. However, the DED_{theo} calculated for the two pollutants are all lower than the tolerable daily intakes (TDI) for Cd and Pb respectively. Indeed, the TDI per ingestion is estimated at 0,83 µg/kg body weight. For Pb, this value is set at 3,5 µg/kg of body weight[21].

3.5.2. Estimation of real dietary exposure

The different values of EDI and Real DED (DED_{real}) calculated for each heavy metal in the different animal species and for each age group are listed in **Table III** below.

Table III : Values of estimated daily intakes and doses in Cd and Pb of meat species

Animal species	Heavy metals	Estimated average concentration (µg/kg)	EDI (µg/pers/day)	DED_{real}(µg/kg.bw/day)		
				Teenager	*Young*	*Adult*
Mutton	Cd	43,90	19,26	0,41	0,28	0,25
	Pb	853,18	374,53	8,05	5,41	4,83
Beef	Cd	29,14	12,79	0,27	0,18	0,16
	Pb	410,88	180,28	3,87	2,61	2,33
Chicken	Cd	43,28	18,99	0,41	0,27	0,24
	Pb	530,18	232,63	5,00	3,36	3,00

Analysis of **Table III** shows that the calculated values of the EDI and the DED (DED_{real}) for Pb are all greater than that calculated for Cd, by a proportion of more than 12 times. This observation is made in all animal species studied. In addition, we note that the "*Teen*" age group has the highest values of Real DED for each heavy metal. We note the following order of predominance for all heavy metals: $DJE_{real\,[Teen]}>DJE_{real\,[Young]}>DJE_{real\,[Adult]}$. This result confirms that teenagers do indeed receive a greater pollution load than young people and adults. This observation is made regardless of the metallic pollutant. Furthermore, the real DED (DED_{real}) of Pb calculated in all age groups for mutton are greater than 3,5 µg/kg body weight. For beef and chicken this value is higher than the TDI, only in the *Teenager* age group.

3.5.3. Risk characterization

3.5.3.1. Calculation of the Danger Quotient (DQ)

The calculated values of the theoretical and real danger quotients are listed in **Table IV**.

Table IV: Values of theoretical and actual danger quotients in Cd and Pb of meat species

Animal species	Heavy metals	Theoretical DQ			Real DQ		
		Teenager	*Young*	*Adult*	*Teenager*	*Young*	*Adult*
Mutton	Cd	0,57	0,39	0,34	0,49	0,34	0,30
	Pb	0,27	0,18	0,16	2,30	1,55	1,38
Beef	Cd	0,57	0,39	0,34	0,33	0,22	0,19
	Pb	0,27	0,18	0,16	1,11	0,75	0,67
Chicken	Cd	0,57	0,39	0,34	0,49	0,33	0,29
	Pb	0,27	0,18	0,16	1,43	0,96	0,86

The analysis of **Table IV** shows that the values of the theoretical danger quotients are all less than 1 for Cd and Pb, and that for all animal species. This indicates that consumers ingesting meat with a contamination threshold less than or equal to the MRC, are probably not exposed to a danger because as long as DQ<1. Moreover, it is observed that the calculated values of the real danger quotient (DQ_{real}) for the Pb are all greater than 1 for mutton for all age groups on the one hand, and for beef and chicken only for the *Teenager* age group on the other hand. However, all values found of Real DQ for Cd are less than 1 for all animal species. These results show that the consumption of mutton *Choukouya* presents a specific danger to the non-threshold effects of Pb because DQ>1. These results show that mutton (DQ=2,30) contributes more in polluting load in Pb, followed by chicken meat (DQ=1,43) and in last position, beef (DQ=1,11).

3.5.3.2. Calculation of Individual Excess Risk (IER)

The preceding **Table VI** has shown that apart from mutton where the DQ>1 for all age groups for Pb, we only observe in beef and chicken for the *Teenager* age group a DQ>1. These results therefore allow us to characterize the IER values only for Pb (non-threshold toxicant) for the different animal species in each age group as listed in **Table V**.

Table V: Individual excess risk values in Pb of meat species

Animal species	Individual excess risk (ERI) for Pb ($mg^2.kg^{-2}$)		
	Teenager	*Young*	*Adult*
Mutton	$1{,}98.10^{-7}$	$1{,}33.10^{-7}$	$1{,}19.10^{-7}$
Beef	$9{,}55.10^{-8}$	-	-
Chicken	$1{,}23.10^{-7}$	-	-

** (-): not calculated because DQ<1*

The observation of the calculated values of the ERI for the different animal species are all lower than the WHO recommendation value which is $10^{-5}mg^2.kg^{-2}$.

4. Discussion

The results of the analysis of the meat species used in *Choukouya* do indeed show contamination of them by Cd and Pb. However, Cd is a cumulative pollutant with a biological half-life of around 20. at 30 years old. Thus, chronic exposure to lead to the appearance of irreversible nephropathy which can progress to renal failure [16], the appearance of deminarilization and weakening of the bones (osteoporosis) and demineralization and bone deformation (osteomalacia) with severe bone pain [25]. As for chronic exposure to Pb, it leads to anemia, lower intelligence quotient, congenital anomalies, neuro-behavioral deficits (severe lead encephalopathy) [15],[26] . Contamination of meat species with Cd and Pb is variable, as Fisher's F-test for homogeneity of variances showed that the differences observed between the metal concentration levels of meat species are significant. This result shows that this metallic contamination depends on the animal species and the type of pollutant. Indeed, beef is one of the best food sources of metals [27],[28] and this, because this meat is exposed to several sources of metals from breeding to his diet. However, the Cd contents for all the samples are lower than the standard, which is not the case for Pb. This situation could be explained by the fact that almost all the *Choukouya* sales sites are located at the edge of roads with large traffic of cars and motorized vehicles. However, vehicle trafficking will be a major source of Pb through atmospheric fallout emanating from motor vehicle exhaust fumes. Our survey also showed that the sanitary cooking and packaging environment is likely to convey more metal pollutants and, preferably, Pb. This finding was corroborated by the studies of Koffi et *al.*[12] and those of Leblanc et al. [29],[30]. In addition, Cd is less metabolized than Pb in animal meat [31]. This is why the accumulation of Pb is preferable than that of Cd in different species of meat with a Pb content above the norm. The fact that mutton accumulates pollutants indicates that this meat under *Choukouya* conditions presents dangers for consumers. Indeed, the DQ>1 for the Pb of consumers of Choukouya mutton of all age groups. There is therefore a danger of the appearance of toxic effects of Pb without it being possible to predict the probability of this event occurring. For other species of meat this danger is observed only in the *Teenager* age group. Authors have indicated in their work [12],[30],[32] that Pb exposures for adolescents are higher than for adults. Indeed, the body of children (*Adolescent*) potentially absorbs more contaminants and remains unable to eliminate them as easily as young people and adults since their elimination systems are less developed [33]. Also, because of their low body weight and their physiological fragility, children will receive a greater pollutant load easily absorbed in their body [34]. The consumers of *Choukouya* meats in Daloa, who are most exposed to the harmful effects of Pb poisoning, are young people. Our study agrees with that of Koffi et *al.* [12] in Cote d'Ivoire, which indicated a dose of 0,53 µg/kg.bw/day for children against 0,017 µg/kg.bw/day for *adults*, or three times the adult dose. Risk characterization has shown that the calculated DQ for Pb in sheep is greater than 1 regardless of the age group. In addition, the DQ>1 for beef and chicken only in the *Teenager* age group. The resulting **IER** is lower than the probabilistic limit set by the WHO. So the likelihood that one in 100.000 young consumers of any age group exposed to Pb will develop carcinogenic effects or cancer over the 5 years of exposure for this study is negligible. This finding is the same for the young and adult age groups in mutton. Because despite a DQ>1, the calculated value of the IER allows this probability of cancer to occur in the exposed population to be neglected.

5. Conclusion

The assessment of the health risks due to Cd and Pb incurred in the consumption of *Choukouya* by the population of Daloa has shown that the different species of meat used are indeed contaminated by metal pollutants. The food survey carried out as part of the risk assessment revealed that the sanitary framework for the sale of *Choukouya*, its cooking method and its packaging would be vectors of metal pollutants. Contamination of meat species by Cd and Pb is variable with a significant difference observed between the metal concentration levels of meat species. However, Pb has a concentration greater than the MRC in all meats, which presents a danger to consumers. Furthermore, the risk characterization showed that the calculated DQ for Pb in sheep is greater than 1 regardless of the age group. In addition, the DQ> 1 for beef and chicken only in the "Adolescent" age group. The resulting ERI is then below the probabilistic limit set by the WHO. However, because Pb is a cumulative toxicant and having effects acting in synergy with other pollutants, consumers of *Choukouya* must instead reduce their frequency of consumption, which could be maintained at once a month. This allows us to say that the probability that a young consumer of *Choukouya* exposed to Pb will develop carcinogenic effects or cancer is negligible.

References

[1] **NorinagaM., TakashiM., KatsuyaT., AsakoK., KazuhiroO.and MiyamotoH.** (1999) :"Bacteriological investigation of an outbreak of Clostridium perfringens food poisoning caused by Japanese food without animal protein". International Journal of Food Microbiology, 49, 103-106, 1999.

[2] **Lindstrom M., Keto R., Markkula A., Nevas M., Hielm S., Korkeala H.** (2001) :**"**Multiplex PCR assay for detection and identification of Clostridium botulinum types A, B, E, and F in food and fecal material".*Applied and Environmental Microbiology*, 67, 5694-5699.

[3] **Hubert B., Loo V., Poirier A., Dascal A. et Fortin E.** (2007) : "Portrait of the geographic dissemination of the Clostridium difficile North American pused-field type1 strain and the épidemiology of difficile-associated disease in Quebec". *Clinical Infectious Diseases*, vol 44, pp. 238-2344.

[4] **Miller M., Gravel D., Mulvey M., Talor G., Boyd D. and Simor A.** (2010) : Health care-associated *Clostridium* difficult infection in Canada : Patient Age and Infecting Strain Type Are Highly Predictive Of Severe Outcome And Mortality. *Clinical Infections Diseases*. Vol 50, pp. 194-201. https://doi.org/10.1086/649213.

[5] **El-Hadef, El Okki S., El-Groud R., Kenana H. and Quessy S.** (2005) : Assessment of the surface contamination of bovine and ovine carcasses from the municipal slaughterhouse of Constantine in Algeria. *Canadian Veterinary Journal*, 46, pp 638-640.

[6] **Fosse J., Cappelier J-M., Laroche M., Fradin N., Giraud and K., Magras C.** (2006) : Beef meat: an analysis of biological hazards for the consumer applied to the slaughterhouse. Renc. Rech. Ruminants, 13, pp 411–414.

[7] **Dibi D., Akmel D. , Tano K., Assidjo N., Akaki D.andMontet D.** (2017) : Quantitative assessment of the risk linked to the consumption of braised beef meat *Choukouya* contaminated with pathogenic Clostridium perfringens in Côte D'Ivoire.*Food and Nutrition Sciences*, 8 (12) : 1137-1155.

[8] **EFSA (European Food Safety Authority)** (2009) : Scientific opinion on Cd in food. *The Efsa journal*, 980 : 1–139.

[9] **EFSA** (2010) : Scientific opinion on Lead in food. *The Efsa journal*, 8(4) : 1–147.

[10] **Boumehres A.**, (2010) : Comparative study of the techniques of extraction of metallic trace elements in liver, kidney and milk and their determination by atomic absorption spectrophotometry (flame and graphite furnace).

[11] **WHO**(2010) : Basic measures to improve the safety of food sold on the public highway. INFOSAN Information Note N 3/2010 Safety of street foods, Geneva, Switzerland, 6p.

[12] **Koffi M., Assi Y., Saki J. et Biego H.** (2014) : Assessment of the population's exposure to trace metals (cadmium, mercury, lead) through the consumption of imported beef and pork meat and offal. *Int. J. Biol. Chem. Sci.* 8(4): 1594-1603. http://ajol.info/index.php/ijbcs .

[13] **Miquel M.**, (2001) : The effects of heavy metals on the environment and health, Report 261, *ParliamentaryOffice for the Assessment of Scientific and Technological Choices*, 365p.

[14] **Picot A.** (2003) : Intoxication of the body by heavy metals and other toxicants. Mercury, lead and cadmium, three toxic trace metals. Conference ADNO, 2003 Paris, 29 nov 2003.

[15] **Bolin C., Basha R., Cox D., Zawia N., Maloney B., Lahiri D. et Cardozo-Pelaez F.** (2006) : Exposure to lead and the developmental origin of oxidative DNA damage in the aging brain. *Faseb. J.*, 20 : 788–790.

[16] **Bisson M., Diderich R., Houeix N., Hulot C., Lacroix G., Lefèvre J.P., Levèque S., Magaud H., Morin A., Pepin G. et Pichard A.** (2011) : Cadmium and its derivatives, Toxicological and environmental data sheet for chemical substances, 82p. [online] URL : http://www.ineris.fr/hml.

[17] **Assidjo E., Sadat A., Akmel C., Akaki D., Elleingad E. et Yao B.** (2013) : Risk analysis: innovative tools for improving food safety. *African Journal of Animal Health and Production*.11(S) : 3-13.

[18] **INS (Institut National de la Statistique)** (2014) : General Census of Population and Housing. Socio-demographic and economic data: Haut–Sassandra region.

[19] **CEAEQ (Centre d'Expertise en Analyse Environnementale du Québec)** (2019) **:**MA analysis method. 200 – Met. 1.2 2020-05-21 (revision 7). *Quebec Center of Expertise in Environmental Analysis*. Ministry of the Environment and the Fight against Climate Change. 35 pages (pp17–25). [Online]. www.ceaeq.gouv.qc.ca/methodes/pdf/MA200Met12.pdf.

[20] **INERIS** (2003) :Lead and its derivatives; toxicological and environmental data sheet for chemical substances, version n ° 2-1 / 2003; 90p.

[21] **FAO/WHO** (2011) : FAO / WHO Guide to the Application of Risk Analysis Principles and Procedures in Food Safety Emergencies. Rome. 60 pp. Site Web: http://www.fao.org/food/food-safety-quality/home-page/fr/

[22] **Persoons R.** (2011) : Study of methods and models for characterizing occupational atmospheric exposure to

chemical pollutants for the assessment of health risks. Doctoral thesis University of Grenoble 250 p.

[23] **INERIS** (2007) :Méthodologie d'évaluation quantitative des risques sanitaires relatifs aux substances chimiques. *Conventions* ADEME/SYPREA/SPDE/INERIS n°0375C0093 et 0675C0071, version 1 du 15 octobre 2007, 45 pages.

[24] **FAO/OMS(Organisation des Nations Unies pour l'alimentation et l'agriculture/Organisation mondiale de la Santé)** (2006) : Analyse des risques relatifs à la sécurité sanitaire des aliments. Rome. ftp://ftp.fao.org/docrep/fao/010/a0822f/a0822f.pdf

[25] **Blierfert C. et Perraud R.** (2008) : *Chimie de l'environnement. Air, eau, sols, déchets*. 2è éd., de Boeck, Bruxelles, pp 369 – 389.

[26] **Bisson M., Hulot C., Lacroix G., Lefèvre J.P., Magaud H., Oberson-Geneste D., Morin A. et Pepin G.** (2003) : Plomb et ses dérivées, Fiche de données toxicologiques et environnementales des substances chimiques, 82p. [en ligne] URL : http://www.ineris.fr/hml.

[27] **Geay Y., Bauchart D., Hocquette J.F., Culioli J.** (2002) :Valeur diététique et qualité sensorielle des viandes des ruminants. Incidence de l'alimentation sur les animaux. INRA Productions Animales, 15,35-52.

[28] **Bauchart D., Chantelot F., Gandemer G.** (2008) :Qualités nutritionnelles de la viande et des abats chez le bovin : données récentes sur les principaux constituants d'intérêt nutritionnel. Cah. Nutr. Diét. 43 (HS1), 1S29-1S39.

[29] **Leblanc J., Guérin T., Verger P., Volatier J.** (2004) : Etude de l'alimentation totale française. Mycotoxines, minéraux et éléments traces. INRA, Ministère de l'Agriculture, de l'Alimentation, de la Pêche et des Affaires Rurales, 72 p.

[30] **Leblanc J., Sirot V., Volatier J., Aouachria N.** (2011) : Etude des consommations alimentaires de produits de la mer et imprégnations aux éléments traces, polluants et oméga 3 (CALIPSO). *Afssa*, Ministère de l'Agriculture et de la Pêche, INRA.

[31] **Panisset J., Dewailly E. et Doucet-Leduc H.** (2003) :Contamination alimentaire. In Environnement et santé publique – Fondements et pratiques. Editions Tec & Doc.

[32] **Noël L., Leblanc J., Guérin T.** (2003). Determination of several elements in duplicate meals from catering stablishment using closed vessel microwave digestion with inductively coupled plasma mass spectrometry detection : estimation of daily dietary intake. *Food Additives and Contaminants*, 20(1): 44-56.

[33] **Hounkpatin A., Edorh A., Salifou S., Gnandi K., Koumolou L., Agbandji L., Aissi K., Gouissi M. et Boko M.** (2012) : Assessment of exposure risk to lead and cadmium via fish consumption in the lacusrian village of Ganvié in Benin republic. *J. Environ. Chem. Ecotoxicol.* Vol. 4(1), pp.1–10, 2 January. Available online at http://www.academicjournals.org/JECE.

[34] **RCAP (Royal Commission on Aboriginal Peoples)** (1996) : Gathering Strength Ottawa, canada Communications group 3 : 185.