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# AFLATOXINS CONTAMINATION IN MAIZE- BASED FOOD AND HUMAN HEALTH IMPLICATION IN BAFIA (CENTRE-CAMEROON)

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## ABSTRACT

**Background:** In sub-Saharan Africa and particularly in Cameroon, several research has shown the presence of aflatoxins (AFs) in food intended to human consumption. The evaluation of the health risk associated with consumption of contaminated foods is needed to know the sanitary statute of the population.

**Objective:** This study was conducted from January to December 2014 in Bafia in the Centre Region of Cameroon with the objectives to determine the levels of AFT ($AFB_1$, $AFB_2$, $AFG_1$ and $AFG_2$) in dishes where maize is the staple food and to estimate the health risk (Body Mass Index, Estimate Daily Intake, Risk Exposure, Risk of Liver Cancer Incidence) among the rural population of Bafia.

  

**Method:** A validated Enzyme Linked Immuno Sorbent Assay was performed to estimate AFT contamination levels in a total of 109 samples of maize-based foods. A food survey was carried out using standard method involving 102 children [5-8 years], 106 adolescents [9-15 years] and 156 adults [>15 years]) and was permit to estimate the average amount of maize -based food

**Results:** AFT were detected in 100% of samples and the levels ranged from 0.8 µg/kg (roasted maize or maize fritters) to 18.6 µg/kg (dry or fresh flat maize cake with groundnuts). Dietary exposure was age-depending. Children were more vulnerable to AFT ($43.77^{c}$ ± 0.56 ng/kg bw/day) followed by adolescents ($31.88^{b}$ ± 0.32 ng/kg bw/day) and finally adults ($27.38^{a}$ ± 0.49 ng/kg bw/day). The same tendency were also obtained concerning the risk of liver cancer incidence/100 000/year attributable to dietary AFT among all subgroups under study ( Children: $0.6^{c}$; Adolescents: $0.4^{b}$; Adults: $0.3^{a}$).

**Conclusion:** This highlights the need for continuous monitoring of maize-based food for AFT and to implement strategies for their control in Cameroon.

**Keywords:** Maize-based food, AFT, dietary intake, health risk, rural population.

**ABBREVIATIONS:**

ALARA: As Low As Reasonably Achievable

$AFB_1$: Aflatoxin $B_1$

$AFB_2$: Aflatoxin $B_2$

$AFG_1$: Aflatoxin $G_1$

$AFG_2$: Aflatoxin $G_2$

AFT: total aflatoxins ($AFB_1$, $AFB_2$, $AFG_1$ and $AFG_2$).

AFs: Aflatoxins

BMI: Body Mass Index

DON: Deoxynivalenol

EDI: Estimate of Daily Intakes

ELISA: Enzyme Linked Immunosorbent Assay

FBs: Fumonisins

  

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OTA: Ochratoxin A

RE: Risk of Exposure

RLCI: Risk of liver cancer Incidence/year/100.000 populations

TDI: Tolerable of Daily Intakes

ZEN: Zearalenone

## INTRODUCTION

Maize (*Zea mays L.*) is the first cereal cultivated in Cameroon and constitutes the very important staple food in the diet of the rural Cameroonian population (Nguegwouo et al., 2011). It is consumed in the form of pap, paste, pancake or grains. It is also used for livestock feeding or for the making of traditional beers, starch for batteries and packaging industries, and for supply to local food processing industries (Breweries, Food industries). Maize grain is susceptible to contamination and degradation by fungi including *Aspergillus, Fusarium and Penicillium spp* (Gamanya and Sibanda, 2001). Contamination effect the quality of grain through discoloration, reduction in nutritional value and production of mycotoxins. Mycotoxins are toxic fungal secondary metabolites that include aflatoxins (AFs), Fumonisins (FBs), Deoxynivalenol (DON), Ochratoxin A (OTA) and Zearalenone (ZEN) (Marin *et al.*, 2013). Globally, it is estimated that aflatoxins are the most important chronic dietary risk fact. Each year, 550,000-600,000 new cases of liver cancer are registered worldwide, and about 25,200-155,000 cases are attributable to aflatoxin exposure, representing about 4.6 -28.2% (WHO, 2008). The retrospective epidemiological survey in hospitals of Bafia (Centre Region, Cameroon) has shown an incidence of 0.8-0.9 deaths from liver cancer for 55 700 inhabitants per year (Anonyme, 2007). The resurgence of cancer in this locality may be due to their geographic position, situated in the humid forest with bimodal rainfall, which enable fungi growth. AFs (figure 1) are naturally occurring toxins produced by certain fungi, most importantly *Aspergillus flavus and Aspergillus parasiticus* and are classified as group1 that means human carcinogen (IARC, 2002; Hove et al., 2016). They may cause liver cancer, suppressed immune systems, and retarded growth and development by contributing to malnutrition Children are more sensitive to the effects of aflatoxin- contaminated food (Tchana et al., 2010). The occurrence of many fungi (*Aspergillus, Fusarium*) and mycotoxins (aflatoxin, fumonisin, zearalenone and so one) in Cameroonian food commodities such as maize, peanuts, beans, soybeans etc. has been reported by many authors. Ngoko et al. (2008, 2001) reported *Aspergillus* sp., *Fusarium* sp. and *Penicillium* sp. as part of the main fungal contaminants of crops in Cameroon. AFs has been detected by Njobeh et al.(2010) in 55% of their samples including maize at concentrations between 0.1-15 µg/Kg. In

  

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2015, the analysis of *Kutukutu*, a fermented maize-based dough largely consumed in the Northern part of the country reveals an aflatoxin $B_1$ content which in some cases exceeded 4 ppb, the European Union standard fixed for such products. Abia et al.(2017)also detected low levels of aflatoxin in Maize-*fufu* (also known as fufu-corn), a boiled maize-dough dish that is consumed especially in the western highland of Cameroon.To the best of our knowledge, there are no studies establishing the link between AFT exposure via consumption of maize-based food and the risk of liver cancer in the rural Cameroonian population. this study was carried out with the aims 1) to quantify the levels of AFT i.e. $AFB_1$, $AFB_2$, $AFG_1$, $AFG_2$ in a total of 109 maize-based food sampled from some villages of Bafia in the Centre of Cameroon and 2) to establish a link between dietary AFT exposure and the risk of human liver cancer.

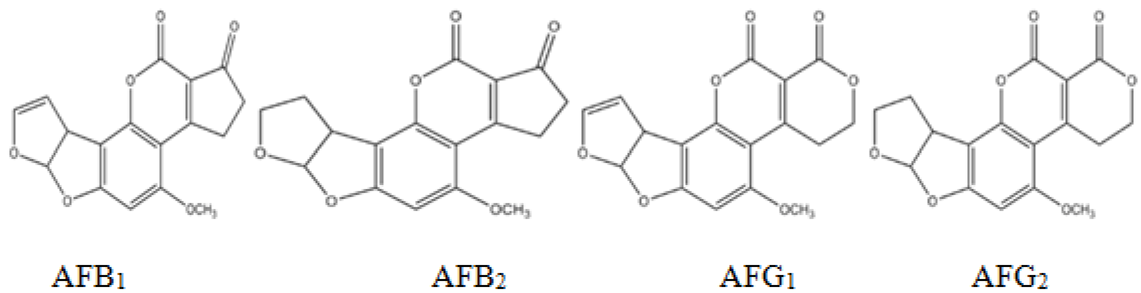

**Figure 1: Chemical structure of principal aflatoxins ($B_1$, $B_2$, $G_1$ and $G_2$)**

## MATERIAL AND METHODS

### *Site description and study design*

This study was conducted in Bafia, one of the administrative subdivision of the Mbam and Ibounou Division in the Centre Region of Cameroon between January and December 2014. It is crossed by the national route N°4 linking Bafoussam to Yaounde. It is located at 120 km North of Yaounde at latitude 4° 45´00´´ North and longitude 11°14´00´´ East. Their total population is about 55700 inhabitants (MINAGRI, 2002).

Bafia was chosen based on the maize consumption and climatic conditions (annual rainfall ranges between 3500 and 4000 mm, average temperature between 27°C and 36.7°C, humidity ranged between 60 and 70% which are favorable to fungi growth and chances of AFs contamination are high. Four villages of Bafia (Donenkeng, Binya, Goufan I, Goufan II and Thekané) were purposively selected

### *Food survey*

  

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A food survey was carried out using the method described by Kroes et al.(2002) in year 2014 based on the collection in the study site of maize-based food consumed by 366 apparently healthy and not fasting individuals divided into 108 children [5-8 years], 102 adolescents [9-15 years],and 156 adults [>15 years] for 7 consecutive days. The objective of this survey was to determine the average amount of maize -based food consumed by the subgroup of Bafia's population, their average body weight and height. Electronic scale was used to estimate the consumption of food. The individual body weight and height of each participant were taken using fathom and human scale respectively.

***Collection of samples***

A total of 109 samples of maize-based food, each weighing approximately 2 kg (consisted of four 500 g subsamples from households) was collected according to the European Commission (EC) No 401/2006 (EC, 2006)from the villages of study site between September and November of the year 2014.Samples included maize beer (n=9); dry or fresh maize cake with vegetables (n=10); dry or fresh maize cake with groundnuts (n=15); maize porridge (n=10); maize fufu or couscous (n=13); maize milk (n=9); vegetables with maize (n=8); roasted maize (n=8); boiled maize (n=9); fried maize with groundnuts(n=10) and maize fritters (n=8) were placed in polyethylene bags and taken immediately to the laboratory. Upon arrival, all food samples were homogenized, finely milled for solid samples and lyophilized for liquid samples before frozen at −20 °C until analysis for AFT.

***Analysis of AFT using quantitative ELISA Test***

AFT ($AFB_1$, $AFB_2$, $AFG_1$ and $AFG_2$) content in each maize-based food was determined using a quantitative competitive direct ELISA (Enzyme Linked Immunosorbent Assay) kit for AFT in cereals and derivatives purchased from Reneekabio (CAT. N° AF012714 Qual, HELICA Biosystems, Inc., Santa Ana, CA, USA). The AFT extraction was conducted according to manufacturer's protocol. For each sample, 20 g of the powder was added to 100 mL of methanol 70%. The mixture was then homogenized for 5 min using a magnetic stirrer, filtered through whatman paper N° 4 and the supernatant used for the ELISA test. The AFT content was inversely proportional to the color intensity established using an automated microplate reader (EL × 800, BIOTEK, Instruments Inc., Winooski, VT, United States) at 450 nm. A calibration curve was plotted using AFT standard at different concentrations (0.2, 2.5, 5, 10 and 20 µg/kg or ppb). Limit of detection (LOD) and limit of quantification (LOQ) for AFT were < 0.01 and 0.01 µg/kg respectively. Samples with AFT levels lower than 0.01 µg/kg were considered as aflatoxin-free The recovery percentage was determined using reference material (FAPAS test material specification sheet, TO4138) from manufacturer.

  

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***Estimate of Body Mass Index, Daily Intake***

The Body Mass Index (BMI) is defined as the body mass (weight) over the square of the body height, and is universally expressed in units of kg/m$^2$. For this study, we used the average BMI of the subgroups (children, adolescents and adults)

$$BMI = \frac{W}{H^2} \qquad (1)$$

With BMI: Body Mass Index (kg/m$^2$);

W: Weight (kg) of each subgroup studied;

H: Height (m) of each subgroup studied.

The Estimate of Daily Intakes (EDI) of AFT contaminated maize-based food were obtained by multiplying individual (Average)intake of maize-based food by the average concentration of AFT in each contaminated food consumed and then summing the contributions of all the maize-based food. These contributions, initially expressed in ng/day (AFT) were divided by mean body weight (b.w) measured for each population subgroup so that they were expressed in ngkg$^{-1}$ body weight/day (AFT) thus facilitating comparison with the toxicological reference values (Tolerable Daily Intake or TDI) proposed by different international bodies. For this study we used 1ng kg$^{-1}$ (b.w.) day$^{-1}$(JECFA, 2001)

$$EDI = \sum \frac{C \times Q}{b.w} \qquad (2)$$

With:

EDI: Estimate of Daily Intakes of AFT in ng kg-1 of body weight (b.w.) day-1;

C: The AFT concentration found in each maize-based food (µg/kg or ng/g);

Q: The daily intake of each maize-based dish (g/day);

bw: The average body weight of the subgroup of the population

***Risk Exposure and Cancer Risk Incidence***

The characterization of the Risk of Exposure (RE) to AFT of each subgroup of population is calculated using the following formula (ASTEE, 2003)**:**

  

$$RE = \frac{EDI}{TDI} \qquad (3)$$

With RE: Risk of Exposure

EDI: Estimate of Daily Intakes of AFT in ng kg-1 of body weight (b.w.) day-1

TDI: Tolerable of Daily Intakes of AFT in ng kg-1 of body weight (b.w.) day-1

If: RE <1 means that the exposed population is theoretically out of danger, that is, this exposed population is not likely to develop the health effects studied.

- RE> 1 means that the toxic effect can occur without being possible to predict the probability of the occurrence of this event.

According to epidemiological data of JECFA (1999), it is considered that ingestion of 1 ng AFT / kg b.w./day would increase the incidence of liver cancer by 0.013 cancer cases per year per 100.000 populations. This suggests that the annual incidence of liver cancer in the rural population of Bafia: 0.013 x EDI (for maize) per 100,000 for each population subgroup studied. Hence, the Risk of liver cancer Incidence (RLCI) can be calculated as follow (JECFA, 1999):

(RLCI) = EDI × 0.013(4)

With RLCI: Risk of liver cancer Incidence/year/100.000 populations

EDI: Estimate of Daily Intakes of AFT in ng kg-1 of body weight (b.w.) day-1

0.013: Constance of liver cancer per year per 100. 000 populations

### *Statistical analysis*

Tree replicates of the data were performed and the data was expressed as means and standard deviation (SD). The homogeneity of the mean concentration of AFT was assessed by an analysis of variance by the Fischer test using SPSS version 10.0 for windows and a “p” < 0.05 was considered as statistically significant.

## RESULTS

### *Anthropometric data of population subgroup studied.*

The Body Mass Index (BMI) is the anthropometric data calculated for this study and results were summarize in Table 1.  BMI was normal for all children and adolescents surveyed. In contrast, some of the adults (19%) were overweight (BMI ≥ 25 $kg/m^2$).

**Table 1: BMI data of subgroup of rural population in Bafia (Centre - Cameroon)**

| Subgroup of rural population in Bafia | Weight (kg) | Height (m) | Body Mass Index BMI (kg/m$^2$) | % of individual's BMI ≥25 |
|---|---|---|---|---|
| Children | 23.2±0.3 | 1.3±0.1 | 13.7±0.9 | 0.0 |
| Adolescents | 34.0±0.3 | 1.4±0.1 | 16.6±0.2 | 0.0 |
| Adults | 56.4±0.8 | 1.7±0.3 | 20.0±0.3 | 19.0 |

***Quality control***

The concentration of AFT in quality control reference material determined by the manufacturer and the concentration we obtained using the ELISA method generated a standard deviation of 8.02 and relative standard deviation was 9.20%. The average recovery rate for AFT at the three spiking concentrations was 105%, standard deviation was 2.30 and relative standard deviation was 2.2%. The calibration curve used for quantification of AFT gave correlation coefficient ($r^2$) of 0.998 and 0.981 for standard solution and matrix-matched calibration, respectively. No cross reactivity was observed, thus, the method was considered specific for this analysis.

***Level of AFT in maize-based food and data on food consumption by subgroup of rural population in Bafia.***

Table 2 provides data on AFT levels in maize–based foods and the average amount consumed per day by rural population in Bafia. AFT were detected in 100% of samples analyzed and varied significantly (P<0.05) between dry or fresh flat maize cake with vegetable, dry or fresh maize cake or also fried maize with groundnuts and other maize-based foods. The levels were ranging from 0.8 µg/kg in roasted maize or maize fritters to 18.3 µg/kg in dry or fresh flat maize cake with groundnuts. A high frequency of occurrence was noted in maize-based food consumed by the rural population. The quantities of average maize-based food consumed on dry weight (g DW) by 108 children (4-8 yrs) and 102 adolescents (9-14yrs) showed significant difference (P<0.05) between dry or fresh flat maize cake with vegetable, dry or fresh maize cake with groundnuts, maize beer, maize porridge and other maize -based food. Foods such as roasted maize (192.9 g DW/day) are mostly consumed by children whereas maize porridge was least consumed (5.5 g DW/day). The average maize-based food consumption among 102 adolescents shown the same things. Average consumption of maize-based foods in g DW/ day of 156 adults showed a significant difference (P<0.05) between dry or fresh flat maize cake with vegetable, dry or fresh maize cake with groundnuts, maize beer, maize porridge, maize milk and other food-based foods. Foods such as roasted maize (219.7 g DW/day), boiled maize (218.4 g DW/day)

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and maize fufu (149.6 g DW/day) were highly consumed than other maize products, while maize porridge was the least consumed food (5.5 g DW/day).

**Table 2: AFT levels in maize-based foods and average food consumption per day by rural population in Bafia.**

| Food type | AFT (µg/kg) n= 109 | Average food consumption (g DW/day) | | |
|---|---|---|---|---|
| | | Children (4-8 yrs) N= 108 | Adolescents (9-14 yrs) N=102 | Adults (≥15 yrs) N= 156 |
| Maize beer | 1.5±0.2[a] | 0 ±0.0[a] | 0±0.0[a] | 2.5± 0.1[a] |
| Dry or fresh flat maize cake with vegetable | 16.8±0.1[b] | 12.1±0.1[a] | 13.4±0.0[a] | 20.7±0.1[a] |
| Dry or fresh flat maize cake with groundnuts | 18.3±0.8[b] | 8.3±0.0[a] | 7.4±0.1[a] | 10.3±0.1[a] |
| Maize- porridge | 0.9±0.1[a] | 5.5±0.1[a] | 5.5±0.0[a] | 5.5±0.0[a] |
| Maize *fufu (couscous)* | 1.2±0.1[a] | 104.3±0.2[b] | 110±0.1[b] | 149.6±0.1[b] |
| Maize milk | 1.1±0.1[a] | 34.8±0.1[b] | 34.8±0.1[b] | 13.6±0.1[a] |
| Maize vegetable | 1.6±0.3[a] | 63.2±0.3[b] | 63.2±0.0[b] | 70.3±0.0[b] |
| Roasted maize | 0.8±0.1[a] | 192.9±0.2[b] | 192.9±0.0[b] | 219.7±0.11[b] |
| Boiled maize | 1.0±0.1[a] | 149.4±0.2[b] | 149.4±0.1[b] | 218.4±0.1[b] |
| Maize fritters | 0.8±0.1[a] | 29.1±0.1[b] | 29.1±0.1[b] | 29.6±0.0[b] |
| Fried maize with groundnuts | 16.8±1.5[b] | 13.3±0.0[a] | 13.3±0.0[a] | 13.2±0.0[a] |

Values for average food consumption are mean ± SD; N: number of individuals; n: number of maize-based samples analysed; Numbers in a column with different superscripted letters are significantly different ($P < 0.05$); DWB: Dry weight basis.

**Table 3: Daily intake of AFT, risk exposure and risk of liver cancer from subgroup of rural's population in Bafia (Centre-Cameroon).**

| Subgroup of Bafia rural population | Estimate Daily Intake (EDI) *(ng/kg bw/day)* | Tolerable Daily Intake (TDI) JECFA (2001) *(ng/kg bw/day)* | Risk of Exposure (RE) | Risk of liver cancer Incidence attributable to dietary aflatoxin |
|---|---|---|---|---|
| Children | 43.8±0.6[c] | | 43.8[c] | 0.6[c] |
| Adolescents | 31.9±0.3[b] | 1 | 31.9[b] | 0.4[b] |
| Adults | 27.4±0.5[a] | | 27.4[a] | 0.3[a] |

Numbers in a column with different superscripted letters are significantly different ($P<0.05$). Mean body weight of rural's population subgroup [children: 23. 2 kg; Adolescents: 34.0 kg; Adults: 56.4 kg].

  

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***Estimate Daily intake of AFT from the rural's population of Bafia, risk of exposure and risk of liver cancer.***

The results of the mean EDI of the different subgroups of the Bafia population surveyed (Table 3) showed the TDI were varied significantly (P <0.05) from one group to another. The were higher in children (43.8 ng / kg bw/day) compared to adolescents (31.9 ng / kg bw / day) and adults (27.4 ng / kg bw / day). The risk of exposure and the risk of liver cancer incidence showed the same tendency that were higher in children (43.8 and 0.6) compared to adolescents (31.9 and 0.4) and adults (27.4 and 0.3) (P<0.05) respectively.). There was a high risk of increased liver cancer incidence associated with high AFT exposure among all subgroups under study.

## DISCUSSION

In this study, the population studied had normal BMI in infants, adolescents and majority of adults, that means this population would not a particularly obesity problem. However, all samples of maize – based food analyzed were contaminated by AFT at different levels. The majority of samples (75%) presented the level of AFT above the regulated maximum limit by the commission European (4 µg/kg). The most contaminated samples were dry or fresh flat maize cake with vegetable, dry or fresh flat maize cake with groundnuts (18.3 µg/kg) and fried maize with groundnuts (16.8 µg/kg). The highest AFT contents of these samples could be explained by poor conditions of drying and storage of maize that is the major ingredient. The maize harvesting time is generally in the rainy season, drying in wet weather is relatively slow, resulting in the proliferation of *Aspergillus*. Similar observations were noticed by (Yogendrarajah et al. 2014). They found high level of AFT in agronomical crops and justified such contamination by temperature, humidity, storage conditions and duration which are key factors in the development of fungi that produce aflatoxins.

Giving that, adverse effect of mycotoxins in the body are directly link to the quantity of contaminated food ingested, a correlation between the amount of food consumed by the population of Bafia and their AFT content was assessed. The results obtained showed that, the amount of maize-based food consumed by the population in Bafia varied with the age of the population and the type of maize-based food. Maize beer was consumed only by adults. This could be explained by the fact that alcoholic beverages were not allowed to children and adolescent consumption. The low level of AFT presented in maize beer and the low quantity of maize beer consumed demonstrate that, the consumption of this maize-based food could be associated with lower adverse AFT effects in the Bafia population.

The most consumed maize-based foods in the three groups were maize fufu (couscous) followed by roasted maize and boiled maize. This could be explained by the food habit of the population

  

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of the region, maize constitute the staple food of population (Nguegwouo et al, 2017). Fufu is consumed associated various sauces. During harvest period, fresh maize is mostly sold and consumed in boiled form or in roasted. These highly consumed maize base foods presented AFT content of 1.2, 0.8 and 1.0 µg/kg (respectively for maize fufu, roasted maize and boiled maize) which are very lower than the maximum recommended value of 4µg/kg. Regarding the highly AFT contaminated samples, althought their consumption amount per type of age were low, the population could be exposed to adverse effect of AFT present in these samples.

In order to verify this hypothesis, the level of exposition of population to the amount of food consumed was assessed. In general, exposure to mycotoxins depends on the degree of exposure and the amount consumed (Marin et al., 2013).

According to literature, the estimate daily intake of AFT by a person is one of the most important parameter used to assess his risk of exposure to the adverse effect.

The consumption of the same maize-based foods was not significantly different in different group of population nevertheless they have different body weights. Children have significantly lower body weight than adolescents and adults. Since EDI depended on body weight, children's was more exposed than adults and adolescents. There was a correlation between EDI and the risk of exposure and the risk of liver cancer incidence (Table 3). Thus, children more were exposed with high risk of liver cancer incidence. Some adults have been shown to be obese and would be more likely to be exposed to acute toxicity due to AFT in the long term (Liu and Wu, 2010). Our target populations were more exposed to AFT than the French and Balkane (Morrocco) population (Soubra, 2008). The estimated exposure of children and adolescents of the Balkane population showed that for AFT, the average level exceeded 1 ng/kg bw/day and children were also more exposed. Children, a specific vulnerable population group, are routinely exposed to many mycotoxins through food in many parts of the world (Etzel, 2014). Data from the risk assessment of $AFB_1$ (Ediage et al., 2014) the most toxic of all types of AFT showed that the calculated exposure for infants as well as adults exceeded the TDI through maize, peanut, and cassava consumption sampling in the three agro-ecological regions of Cameroon (the western highland, the humid forest with monomodal rainfall and the humid forest with bimodal rainfall). These authors recommended that particular attention should be paid to $AFB_1$, especially in populations with a very high prevalence of Hepatite B virus (10%). Vulnerable groups and/or individuals (such as elderly or immune-compromised people and pregnant women) living in these study zones should be alerted to the potential danger arising from the consumption of mycotoxin-contaminated foodstuffs. For aflatoxins, where carcinogenity is the basis of concern, TDIs are not applicable. Exposure of as little as <1 ng/kg bw/day to AFs can lead to a risk of liver cancer and because of this, a numerical TDI for aflatoxins could not be established.

Therefore, it is recommended that levels of AFT should be as low as technologically feasible or as low as reasonably achievable (ALARA). Nevertheless, TDIs of 1 ng/kg bw/day have been used in other risk assessment (Etzel, 2014; Matumba, 2014).

The ratio of (EDI) to (TDI) was determined to assess the risk of exposure of rural's consumers. It has been noted that the EDI value of AFT ingested per maize-based food exceeded nearly 44 times the TDI in children, 32 times in adolescents and 27 times in adults. In the three subgroups of the population, all subjects (100%) exceeded the TDI. This means that the toxic effects can occur without enabling prediction of the probability of the occurrence of this event.

Our study demonstrated for the first time in Cameroon the risk of liver cancer Incidence/100 000/year attributable to dietary AFT. The risk of liver cancer incidence was associated with the high AFT exposure. This parameter was high in children compared to other subgroups of the study population. Aflatoxins in foods are converted to the aflatoxin-8,9-epoxide metabolite in the liver which seems to be responsible of many of the toxic effects in the body (Groopman et al., 2008). Epidemiological studies in Bafia on the pathologies caused by AFT are needed to reinforce the results obtained.

## CONCLUSION

This study clearly demonstrated that AFT were present in all maize- based products analyzed with children being most at risk. Presently, there are no regulations for mycotoxins in maize-based food intended to human consumption in Cameroon, however the urgency is reported for the routine monitoring of these foods. We recommend that for staple foods, the maximum level should be reconsidered in specific case of Cameroon with more restriction than for other foods. Furthermore, awareness/educational interventions are required to enhance caregiver adherence to consumption advice for specific foods while adopting good hygiene and preparation practices.

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## REFERENCES

Abia, W.A., Warth, B., Ezekiel, C.N., Sarkanj, B., Turner, P.C., Marko, D., Krska, R., Sulyok, M., 2017. Uncommon toxic microbial metabolite patterns in traditionally home-processed

  

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maize dish (fufu) consumed in rural Cameroon. Food Chem. Toxicol. 107, 10–19. https://doi.org/10.1016/j.fct.2017.06.011

Anonyme, 2007. Cas de décès dus au cancer du foie et de l'œsophage dans les hôpitaux de Donenkeng et de Bafia de 1999 à 2007. Hôpital de Bafia.

ASTEE, 2003. Guide pour l'évaluation du risque sanitaire dans le cadre de l'étude d'impact d'une U.I.O.M. Assoc. Sci. Tech. l'Eau l'Environnement 60p.

EC, 2006. Commission Regulation (EC) No 401/2006 of 23 January 2006 laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs. Off. J. Eur. Union.

Ediage, E.N., Hell, K., Saeger, S. De, 2014. A Comprehensive Study To Explore Di ff erences in Mycotoxin Patterns from Agro-ecological Regions through Maize, Peanut, and Cassava Products: A Case Study, Cameroon. J. Agric. Food Chem. 62, 4789–4797. https://doi.org/10.1021/jf501710u

Etzel, R.A., 2014. Reducing Malnutrition : Time to Consider Potential Links Between Stunting and Mycotoxin Exposure ? Pediatrics 134, 4–8. https://doi.org/10.1542/peds.2014-0827

Gamanya, R., Sibanda, L., 2001. Survey of Fusarium moniliforme (F. verticillioides) and production of fumonisin B1 in cereal grains and oilseeds in Zimbabwe. Int. J. Food Microbioliology 71, 145–149.

Groopman, J.D., Kensler, T.W., Wild, C.P., 2008. Protective Interventions to Prevent Aflatoxin-Induced Carcinogenesis in Developing Countries. Annu. Rev. Public Health 28, 187–203. https://doi.org/10.1146/annurev.publhealth.29.020907.090859

IARC, 2002. International Agency for Research on Cancer Monographs on the Evaluation of Carcinogenic Risks To Humans: Some Traditional Herbal Medicines, Some Mycotoxins, Naphthalene and Styrene. IARC Press & World Health Organization, Lyon, France. https://doi.org/10.1002/food.19940380335

JECFA, 2001. Joint FAO/WHO expert committee on food additives and contaminants safety evaluation of certain mycotoxins in food. WHO Food Additives Series 47, FAO food.

JECFA, 1999. Joint FAO/WHO expert committee on food additives and contaminants evaluation of certain food additives and contaminants. 49th WHO Technical Report.

  

ISSN: 2455-6939

Volume: 06, Issue: 01 "January-February 2020"

Kroes, R., Mu, D., Massey, R., Mayer, S., Urieta, I., Verger, P., Visconti, A., 2002. Assessment of intake from the diet. Food Chem. Toxicol. 40, 327–385.

Liu, Y., Wu, F., 2010. Global Burden of Aflatoxin-Induced Hepatocellular Carcinoma : A Risk Assessment. Environ. Health Perspect. 118, 818–825. https://doi.org/10.1289/ehp.0901388

Marin, S., Ramos, A.J., Cano-Sancho, G., Sanchis, V., 2013. Mycotoxins: occurrence, toxicology, and exposure assessment. Food Chem. Toxicol. 60, 218–237. https://doi.org/10.1016/j.fct.2013.07.047.

Matumba, L., 2014. Understanding and tackling the complexity of the mycotoxin problem in sub-saharan Africa: regulations and decontamination strategies. PhD thesis, Ghent University, 197p.

MINAGRI, 2002. Rapport annuel d'activités de la délégation de l'agriculture du Mbam.

Ngoko, Z., Imele, H., Kamga, P.T., Mendi, S., Mwangi, M., Bandyopadhyay, R., 2008. Fungi and mycotoxins associated with food commodities in Cameroon. J. Appl. Biosci. 6, 164–168.

Ngoko, Z., Marasas, W.E.O., Rheeder, J.P., Shephard, G.S., Wingfield, M.J., Cardwell, K.E., 2001. Fungal Infection and Mycotoxin Contamination of Maize in the Humid Forest and the Western Highlands of 29, 352–360.

Nguegwouo, E., Fokou, E., Ngoko, Z., Etoa, F., 2011. Corn production, preservation, and transformation in Bafia (Centre Cameroon) and risk assessment of fumonisins contamination. Cameroon J. Biol. Sci. 19, 11–25.

Nguegwouo, E., Njumbe Ediage, E., Njobeh, B., Medoua Nama, G., Ngoko[5]Z., Fotso,M., De Saeger,S.

Fokou,E., F-X. Etoa, F-X., 2017. Aflatoxin and Fumonisin in Corn Production Chain in Bafia, Centre Cameroon: Impact of Processing Technique. *Journal of Pharmacy and Pharmacology*, *David Publishing*. 5, 579-590. Doi : 17265/2328-2150/2017.08.014.

Njobeh, P.B., Dutton, M.F., Koch, S.H., Mosonik, J.S., 2010. Simultaneous occurrence of mycotoxins in human food commodities from Cameroon. Mycotoxins Res. 26, 47–57. https://doi.org/10.1007/s12550-009-0039-6

  

ISSN: 2455-6939

Volume: 06, Issue: 01 "January-February 2020"

Hove, M., Van Poucke, C., Njumbe-Ediage, E., Nyanga, L. K., & De Saeger, S. (2016). Review on the natural co-occurrence of 723 AFB1 and FB1 in maize and the combined toxicity of AFB1 and FB1. Food Control, 59, 675–682.

Soubra, L., 2008. Toxic risk assessment of specific chemical substances and contaminants (Food additifs and Mycotoxins). Thèse de Doctorat Ph.D, Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech), 225p.

Tchana, A.N., Moundipa, P.F., Tchouanguep, M., 2010. Aflatoxin Contamination in Food and Body Fluids in Relation to Malnutrition and Cancer Status in Cameroon. Int. J. Environ. Res. Public Health 7, 178–188. https://doi.org/10.3390/ijerph7010178

WHO, 2008. The Global Burden of Disease: 2004 update. World Heal. Organ. https://doi.org/https://doi.org/10.1038/npp.2011.85

Yogendrarajah, P. Jacxsens, L., Lachat, C., Walpita, C.N., Kolsteren, P., De Saeger, S., De Meulenae, B. 2014. Public Health Risk Associated with the Cooccurrence of Mycotoxins in Spices Consumed in Sri Lanka. Food Chem Toxicol. 74, 240–248. https://doi.org/10.1016/j.fct.2014.10.007

  