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Mycotoxin Contamination of Food and Associated Health Risk in Cameroon: A 25-years Review (1993-2018)

Evelyne Nguegwouo[1,2*], Alex Tchuenchieu[1,3], Hippolyte Mouafo Tene[1], Elie Fokou[2], Gabriel Medoua Nama[1], Sarah De Saeger[4] and François-Xavier Etoa[3]

[1]Centre for Food and Nutrition Research, IMPM, P.O.Box 6163, Yaoundé, Cameroon.
[2]Department of Biochemistry, University of Yaoundé I, P.O.Box 812, Yaoundé, Cameroon.
[3]Department of Microbiology, University of Yaoundé I, P.O.Box 812, Yaoundé, Cameroon.
[4]Laboratory of Food Analysis, Department of Bioanalysis, Ghent University, Ghent B-9000, Belgium.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Gross Domestic Product of Cameron is partially based on agricultural products. Crops like maize, peanuts, beans, cassava, cocoa and coffee are the most cultivated ones. A high portion of this production is locally consumed, and the other part is exported to foreign countries in order to balance the economy. Postharvest losses due to fungal contamination and the presence of mycotoxins in food represent some of the most important problems this producing country government and populations are facing. The analysis of food from animal or vegatal origin in this country during the last 25 years have highlighted the presence of mycotoxins such as aflatoxins, fumonisins, ochratoxins, zearalenone and deoxynivalenol in some cases. This paper reviews the effects of mycotoxins on human health and associated regulations, their occurrence in food commodities from Cameroon, as well as the dietary exposure of consuming populations and the results obtained from their bio-monitoring.

Keywords: Foods; mycotoxins; occurrence; exposure; bio-monitoring; Cameroon.

1. INTRODUCTION

Part of the Cameroonian economy relies on agriculture. The World Bank Group has estimated that the agricultural sector's share in the Gross Domestic Product (GDP) of this country in 2016 was 16.7%. Maize, peanuts, cassava, sorghum, cocoa and coffee represent

**Corresponding author: Email: nguegwouo@yahoo.fr;*

the main crops contributing to this agricultural GDP [1]. These crops are highly consumed by local populations and are also exported all over the world. Cameroon, like many other countries worldwide, faces the serious challenge of post-harvest losses which are partially due to mould contamination [2]. The tropical climate (high temperature and humidity) and the poor crop storage conditions are frequently conducive to the fungal growth [3]. This contamination may occur during cultivation, harvesting or storage and lead to the presence of mycotoxins in the food [4,5]. Mycotoxins are secondary metabolites produced by some fungi and have a negative impact on human and animal health. They are produced by certain moulds species, mainly belonging to *Aspergillus*, *Penicillium* and *Fusarium* genera. Aflatoxins (AFs), fumonisins (FBs), ochratoxins, zearalenone (ZEN) and deoxynivalenol (DON) are the ones of major agro-economic and public health importance [6,7]. These toxins are regularly detected worldwide in several crops such as those previously mentioned. Mycotoxins contamination is nowadays considered as an important quality and safety parameter for foods. The Food and Agricultural Organization [8] has estimated that about 25% of the world's food crops are significantly contaminated with mycotoxins annually. In order to limit the associated health risk, strict standards on the maximum tolerable concentration of different mycotoxins in foods have been fixed at both national and international levels. These toxins account for millions of US dollars lost annually worldwide regarding human and animal health, and destructed agricultural products [9-12]. This paper reviews mycotoxins effect on human health and associated regulations, their occurrence in food commodities from Cameroon over the past 25 years (1993-2018), as well as the dietary exposure of populations and the results obtained from their bio-monitoring.

2. EFFECT OF MYCOTOXINS ON HUMAN HEALTH AND ASSOCIATED REGULATIONS

Human contamination with mycotoxins can occur directly through the consumption of foods containing mycotoxins or indirectly through consumption of animals in which mycotoxins have been bio-accumulated. Table 1 presents the impact of the most common mycotoxins (Aflatoxins, fumonisins, ochratoxins and so on) on human health, together with their producing moulds. Mutagenic, hepatotoxic, dermonecrotic, nephrotoxic, haematotoxic, immunosuppressive, neurotoxic, carcinogenic and teratogenic effects have been reported on both humans and animals [24] and vary from one mycotoxin to another. Besides these mycotoxins commonly found in foods which caused many outbreaks worldwide [25,26], there are also new emerging mycotoxins like fusaroproliferin, gliotoxin, cyclopiazonic acid, penitrem A and verruculogen for which toxicological studies are still ongoing [27-31].

Due to their potential negative impact on health, norms on the level of mycotoxins in marketed and consumed foods have been established worldwide. Based on the toxicological studies, a maximum acceptable content of each specific mycotoxin in different food matrices has been defined at both national and international levels. Some African countries like South Africa, Morocco, Egypt or Zimbabwe have their regulations [32,33,34,35-40], but the most updated and worldwide used regulations are those of developed countries (European Union and USA) [41-50]. Their standards (Table 2) serve as a reference to many other countries from which they import foods. Indeed, they are the main importers of many crops and food products and are strict on the maximum tolerated limits of mycotoxins.

The application of these measures has helped in limiting the mycotoxicoses risk. Nevertheless, this implies additional costs for quality control and eventual rejection of foods once arrived at the destination. Unfortunately, many agricultural products originally destined for export are often put aside and destroyed due to their high mycotoxin content thus affecting the economy of producing countries [9-12]. Many of the countries exporting their food products are developing or underdeveloped countries, where monitoring of the entire production chain from farms to the final products is a challenge [6,51]. Situations where exporting countries would retain higher risk commodities for their national consumption and therefore expose their populations also exist [3]. In fact, the risk of contaminated foods to be consumed locally after market rejection or use for feeding animals is important leading to the possibility to exposure to high levels of contamination and/or appearance of residues in food from animal origin (milk).

Table 1. Effects of the most common mycotoxins on human health

Mycotoxins	Producing moulds	Effects	References
Aflatoxin B_1, B_2, G_1, G_2 and M_1	*Aspergillus flavus, A. parasiticus, A. nomius, A. arachidicola, Emericella astellata, E. venezuelensis, E. olivicola*	Hepatocarcinogenic, carcinogenic, immunosuppressive, genotoxic, oncogenic	[13-15]
Ochratoxin A	*Penicillium verrucosum, A. ochraceus*, *A. carbonarius, A. melleus, A. alutaceus, A. alliaceus, A. albertensis*	Mutagenic, teratogenic, neurotoxic, hepatotoxic, and immunotoxic	[8,15,16]
Fumonisins	*Fusarium verticillioides, F. proliferatum,F. anthophilum, F. dlamini, F. napiforme, F. nygamai, Alternaria alternata*	Esophageal and liver carcinogens, neurotoxic, Genotoxic	[17,18]
Zearalenone	*Fusarium graminearum, F. culmorum* *F. crookwellense.F. equiseti*	Decreased fertility, precocious puberty, breast cancer, endometrial carcinoma, hyperplasia of uterus	[19]
Trichothecenes	*Fusarium graminearum, F. culmorum, F. crookwellense, F. sporotrichioides, F. poae, F. tricinctum, F. acuminatum, Cephalosporium* sp., *Myrothecium* sp., *Trichodermasp., Trichothecium* sp., *Phomopsis* sp.,	Cytotoxic, genotoxic, immunosuppressive, development of autoimmune diseases, anorexia, rectal bleeding, and diarrhoea	[15,18,20,21]
Patulin	*Penicillium expansum, Aspergillus clavatus, Byssochlamys nivea, A. longivesica, A. terreus*	Neurotoxic, genotoxic, teratogenic, immunotoxic, immunosuppressive and carcinogenic effects	[15,22]
Ergot alkaloids	*Claviceps purpurea, C. paspali, C. africana, C. fusiformis*	Abdominal pain, burning sensation of the skin, insomnia, hallucinations and gangrene	[23]

Table 2. Regulated maximum level for the most common mycotoxins found in foods

Country /Region	Mycotoxins	Foods	Maximum level (µg/kg)	References
European Union	Ochratoxin A	Cereals, dry fruits, wine, spices, oat, raisins, coffee, cocoa, soybeans, meat	0.5 – 15	[41]
	Ochratoxin A	Wheat, barley and rye	5	[42]
	Aflatoxins B_1, G_1, B_2, G_2	Maize, wheat, rice, spices, almonds, oil seeds, dried fruits, cheese	0.1–8 4–15	[43]
	Aflatoxin M_1	Milk, eggs, meat	0.5	[42]
	Patulin	Apples, cherries, cereal grains, grapes, pears, bilberries	10–50	[44]
		Apple juice	50	[42]
	T-2 and HT-2	cereals for direct human consumption	50	[45]
		Oats, Barley (including malting barley) and maize	200	[45]
		Wheat, rye and other cereals	100	[45]
	Deoxynivalenol (DON)	wheat, oats and maize	1250	[44]
		Flour, meal, semolina and flakes derived from wheat, maize or barley	1000	[42]
		Cereal grains (wheat, maize and barley) destined for further processing	2000	[42]
	Fumonisins (FB_1 and FB_2)	Maize-based breakfast cereals and maize-based snacks	800	[44]
		Raw maize grain	4000	[42]
		Maize flour and maize meal	2000	[42]
		Maize intended for direct human consumption	1000	[44]
	Zearalenone	Unprocessed cereals other than maize	100	[44]
		Maize intended for direct human consumption, maize-based snacks and maize-based breakfast cereals	100	[44]
		cereal flour, bran and germ for direct human consumption	75	[44]
USA	Total Aflatoxins	Food for human consumption	20	[46]
		Corn, peanut products, cottonseed meal	20	[47]
	Aflatoxin M_1	Milk, milk products	0.5	[46]
	Aflatoxins B_1, B_2, G_1, G_2	Maize, wheat, rice, peanut, sorghum, pistachio, almond, ground nuts, tree nuts, figs, cottonseed, spices	20	[47]
	Deoxynivalenol (DON)	Cereals, cereal products for human food	1000	[48]
	Total Fumonisins (FB_1, FB_2 and FB_3)	Cereals	2000 - 4000	[49]
		Corn products and cleaned maize used for popcorn	2000 - 3000	[49]
	Patulin	Apples, apple juice, and concentrate	50	[49]
	Ochratoxin A	Cereals, wheat, barley, and rye and derived products.	5	[50]

3. OCCURRENCE OF MYCOTOXINS IN FOOD COMMODITIES IN CAMEROON

The occurrence of many mycotoxins in Cameroonian food commodities such as maize, peanuts, beans and soybeans has been reported by many authors (Table 3). Njobeh et al. [52] observed high contamination of these foods from different parts of the country by moulds of the *Aspergillus* and *Penicillium* genera, including toxinogenic strains.

Maize is one of the most vulnerable foods to moulds contamination. Ngoko et al. [53,54] reported *Aspergillus* sp., *Fusarium* sp. and *Penicillium* sp. as the main fungal contaminants of this crop in Cameroon. These authors detected the presence of fumonisin B_1 (FB_1), DON and ZEN at levels which were going up to 26000, 1300 and 1100 µg/kg, respectively. FB_1 was showing the highest prevalence with a concentration increasing with the storage time. The presence of these three mycotoxins in other maize samples from Cameroon was also reported in concentrations which were within the previously mentioned range [55,56]. AFs were also detected by Njobeh et al. [55] in 55% of their samples at concentrations between 0.1-15 µg/kg. This was not the case for Kana et al. [57] who rather observed a prevalence of 9%, the maximal concentration obtained being 42 µg/kg. This toxin content appeared to depend on the agro-ecological zones. The average total aflatoxins level of positive maize samples from the Sahelian Zone was 2.4 µg/kg while positive samples from the Western High Plateau (characterized by its hot climate and high relative humidity) contained 11.9 µg/kg. The studies performed by Njumbe et al. [58] with a more accurate and reliable method (LC-MS/MS) showed levels of contamination of maize which could go up to 5412 µg/kg for FBs, 645 µg/kg for AFB_1 and 3842 µg/kg for DON. Several other studies have also been carried out to assess the presence of mycotoxins in maize derived products which are directly consumed by populations. In 2015, the analysis of *kutukutu*, a fermented maize-based dough largely consumed in the Northern part of the country revealed an AFB_1 content which in some cases exceeded the 2 µg/kg European Commission standard limit fixed for such products [59]. Nguegwouo et al. [60] noticed that AFs and FBs contents of maize-based dishes (beer, porridge, fufu and so on) were dependent on the production process. Processes including a sieving step led to lower mycotoxin concentrations. Similar results were obtained by Abia et al. [61] who also detected low levels of mycotoxins (AFB_1, the bacterial toxin cereulide, DON, FB_1, nivalenol, patulin, ZEN and so on) in maize-*fufu* (also known as fufu-corn), a boiled maize-dough dish that is consumed especially in the western highland of Cameroon. However, this study revealed for the first time in a Cameroonian food the mixture of cereulide, patulin and ZEN derivatives.

Peanuts, beans and soybeans are also often prone to fungal contamination. Non-mycotoxigenic as well as mycotoxigenic moulds of *Aspergillus* and *Penicillium* genera have been isolated from samples coming from different parts of the country [52]. An evaluation of the mycotoxin content in peanuts by Njobeh et al. [55] showed average values of 517, 70, 123 and 6.5 µg/kg for FB_1, ZEN, DON and AFs, respectively. A concentration of AFs between 39-950 µg/kg was even reported in peanuts meal destined for poultry feeds [57]. Njumbe et al. [58] also detected OTA contamination in 13 of the 90 peanuts tested samples (6−125 µg/kg). With beans and soybeans, Njobeh et al. [55] also reported an average concentration of 727 and 195 µg/kg for FB_1, 25 and 110 µg/Kg for DON, 2.4 and 2.1 µg/Kg for AFs, respectively. No presence of ZEN was detected in soybeans by these authors while in beans they noticed an average content of 46.7µg/kg. Abia et al. [56] detected FB_1 in 18 of the 35 peanuts samples they collected and in all ten soybeans samples, at a mean amount of 5 and 49 µg/kg, respectively.

Cocoa and coffee are food commodities with a high impact on the economy of many producing countries like Cameroon. Unfortunately, these latter are also often contaminated by ochratoxin A (OTA). Due to their high level of consumption, strict standards have been defined for these foods, and they are highly controlled on the international markets. The presence of ochratoxigenic fungi like *Aspergillus niger* and *Aspergillus carbonarius* has already been reported in cocoa samples from Cameroon [72]. Studying the effect of post-harvest treatment on the final OTA content in cocoa beans or their derived products (roasted cocoa, nibs, butter, cocoa powder, chocolate spread), Mounjouenpou et al. [62,72,73] observed that pod damage, and late pod opening were aggravating factors for OTA contamination. Fermented dried cocoa from intact pods presented an OTA content below those from poor quality pods (intentionally or naturally damaged) which showed contents of up to 76 µg/kg [73]. *A. carbonarius* and *A. niger* have also

Table 3. An overview of mycotoxins occurrence in some Cameroonian food commodities

Food commodity	Method of analysis	Number of samples	Mycotoxin detected	Frequency of mycotoxin-positive samples (%)	Mean (Range) concentration (µg/kg)	References
Maize	ELISA	18	Fumonisin B_1	NS	(300−26000)	[53]
			Deoxynivalenol	NS	(<100−1300)	
			Zearalenone	NS	(<50−110)	
	ELISA	18	Fumonisins	89	(50-26000)	[54]
			Deoxynivalenol	NS	(100-1300)	
			Zearalenone	NS	(50-180)	
	TLC+ HPLC	40	Fumonisin B_1	65	3684 (37–24225)	[55]
			Zearalenone	78	69 (28–273)	
			Deoxynivalenol	73	59 (18–273)	
			Aflatoxins	55	1.5 (0.1–15)	
	LC-MS/MS	37	Fumonisin B_1	100	508 (2-2313)	[56]
	Aflatest immunoaffinity column+HPLC	77	Aflatoxins	9	1 (≤2–42)	[57]
Maize kernels	LC-MS/MS	165	Fumonisins	74	(10-5412)	[58]
			Aflatoxin B_1	22	(6−645)	
			Zearalenone	14	(27−334)	
			Deoxynivalenol	12	(27−3842)	
Kutukutu (a fermented maize-based dough)	ELISA	29	Aflatoxin B_1	100	(≤2.8)	[59]
Maize-based dishes	ELISA + LC-MS/MS	22	Aflatoxins	100	(0.8-20)	[60]
			Fumonisins	100	(10-5990)	
Maize-*fufu*	LC-MS/MS	50	Aflatoxin B_1	24	0.9 (n.d-1.8)	[61]
			Deoxynivalenol	100	23 (14-55)	
			Fumonisin B_1	100	151 (48-709)	
			Nivalenol	100	268 (116-372)	
			Patulin	30	105 (12-890)	
			Zearalenone	100	49 (5-150)	
Peanuts	TLC+ HPLC	16	Fumonisin B_1	19	517 (25–1498)	[55]
			Zearalenone	63	70 (31–186)	

Food commodity	Method of analysis	Number of samples	Mycotoxin detected	Frequency of mycotoxin-positive samples (%)	Mean (Range) concentration (µg/kg)	References
			Deoxynivalenol	75	123 (17–270)	
			Aflatoxins	75	6.5 (0.1–13)	
	LC-MS/MS	90	Aflatoxin B_1	29	(0.3−12)	[58]
			Ochratoxin A	13	(6−125)	
Peanuts meal	Aflatest immunoaffinity column+HPLC	41	Aflatoxins	100	161 (39–950)	[57]
Groundnuts	LC-MS/MS	35	Aflatoxin B_1	97	47(<LOQ-210)	[56]
Beans	TLC+ HPLC	15	Fumonisin B_1	20	727 (28–1351)	[55]
			Zearalenone	33	48 (27–157)	
			Deoxynivalenol	47	25 (13–35)	
			Aflatoxins	33	2.4 (0.2–6.2)	
Soybeans	TLC+ HPLC	5	Fumonisin B_1	40	195 (25–365)	[55]
			Zearalenone	0	-	
			Deoxynivalenol	40	110 (13–207)	
			Aflatoxins	40	2.1 (0.2–3.9)	
Cocoa beans	Immunoaffinity column+HPLC	36	Ochratoxin A	NS	11.52 (5.3-21)	[62]
Arabica coffee	Immunoaffinity column + HPLC	104	Ochratoxin A	NS	(0.12-124)	[63]
Robusta coffee	Immunoaffinity column+HPLC	48	Ochratoxin A	75	0.6-18	[64]
Arabica coffee	Immunoaffinity column+HPLC	51	Ochratoxin A	65	0.3-4.9	[64]
Green coffee beans	HPLC	7	Ochratoxin A	57	1.7 (1-2.5)	[65]
Sorghum (Variety Damugari)	ELISA	NS	Aflatoxin B_1	75	(0-230)	[66]
Sorghum (Variety Djigari)	ELISA	NS	Aflatoxin B_1	45	(0-145)	[66]
Sorghum beer (*Bil-bil*)	ELISA	70	Deoxynivalenol	100	450 (140-730)	[67]
			Fumonisin B_1	79	150 (0-230)	
Sorghum beer (*Kpata*)	ELISA	50	Deoxynivalenol	74	520 (0-680)	[67]
			Fumonisin B_1	100	210 (0.5-340)	
Stored Cassava chips	ELISA	72	Aflatoxins	33	(5.2 - 15)	[68]

Food commodity	Method of analysis	Number of samples	Mycotoxin detected	Frequency of mycotoxin-positive samples (%)	Mean (Range) concentration (µg/kg)	References
Cassava products (flakes+chips)	LC-MS/MS	165	Aflatoxin B_1	25	(6−194)	[58]
			Penicillic acid	6	(25−184)	
Miscellaneous (Rice, pumpkin seeds "*egusi*", fermented cassava flakes "*gari*", fermented cassava flour "*nkum nkum*")	TLC+ HPLC	6	Fumonisin B_1	0	-	[55]
			Zearalenone	17	67	
			Deoxynivalenol	50	25 (13−35)	
			Aflatoxins	17	0.3	
Eggs	HPLC	62	Aflatoxins	45	0.82 ± 1.7	[69]
Cow milk	ELISA	63	Aflatoxin M_1	16	0.006-0.53	
Black pepper	ELISA	20	Ochratoxin A	10	1.5 (1.2–1.9)	[70]
White pepper	ELISA	20		40	3.3 (1.8–4.9)	
Breast milk	ELISA	42	Aflatoxin M_1	38	7.4 (0.9-37)	[71]

**NS, Not specified; ELISA, Enzyme-Linked Immuno-Sorbent Assay; TLC, Thin Layer Chromatography; HPLC, High-Performance Liquid Chromatography; LC-MS/MS, Liquid Chromatography coupled with Magnetic Sector Mass Spectrometers* been reported by Nganou et al. [63] as the main fungal contaminant of coffee beans from Cameroon, followed by *A. ochraceus*. Among the 104 samples they tested, just a few presented an average OTA content above the 5 µg/kg international limit for roasted coffee. Similar observations were made by Mounjouenpou et al. [64]. Their local Arabica coffee brand samples were all below the limit, and only few from the Robusta coffee were above. Studies conducted by Romani et al. [65] had already shown an OTA contamination of green coffee beans from Cameroon between 1 and 2.5 µg/kg.

The occurrence of mycotoxins in sorghum and its derived products has also been studied during the last decade. This cereal is a crop mainly produced and consumed in the Northern part of the country. No presence of OTA, DON and FB_1 were detected in the grains collected in this region by Djoulde [66]. Only AFB_1 was detected in sorghum cultivated in the rainy season (0-230µg/kg). In some locally produced artisanal sorghum by-products (beer, flour, baby's beverage, and cake), mycotoxins were detected at levels ranging between 0-250 mg/kg for AFB_1, 0-45 mg/kg for OTA, and 0-538 µg/kg for DON. In a previous work performed by this author [67], he observed that the local sorghum beers b*il-bil* and *kpata*, were contaminated by both DON (0-730 µg/L) and FB_1 (0-340 µg/L).

Apart from maize, peanuts, beans, soybeans, cocoa, coffee and sorghum, the mycotoxin content of other foods from Cameroon have also been studied. Essono et al. [68] assessed the total aflatoxin content in cassava chips, a cassava derived product (obtained after fermentation and drying) which is widely consumed locally. They reported contamination of 33% of their samples at levels ranging between 5.2-15 µg/kg. A higher range of aflatoxin content (6-194 µg/kg) in these cassava products (flakes and chips) was noticed by Njumbe et al. [58] who also reported the presence of penicillic acid inside (25-184 µg/kg). Tchana et al. [69] observed AFs contamination in eggs samples (45.2%) at a mean concentration of 0.82 µg/kg, contamination which was varying from one climatic region to another. Indeed, the frequency of contamination ranged from 25 to 53%, forest and mountain climatic areas showing a higher contamination level compared to littoral, and savannah and steppe. These authors also noticed aflatoxin M_1 (AFM_1) contamination in 16% of their cow milk samples at levels varying from 0.006 to 0.525 µg/L. More recently, the presence of OTA was detected by Nguegwouo et al. [70] in 10% of black pepper samples (1.2-1.9 µg/kg) and 40% of their white pepper samples (1.8-4.9 µg/kg) collected from Yaoundé markets.

4. DIETARY EXPOSURE AND BIO-MONITORING

Health risks associated with mycotoxins mainly depend on the consumption frequency of contaminated foods, the level of contamination and on the weight of consumers. On the basis of published data on the consumption of artisanal home-brewed sorghum beer (*bil-bil* and *kpata*) in Cameroon, Djoulde [67] estimated that there are no DON or FB_1 health risks for adults of 60 kg even at the maximum detected concentrations of these toxins (730 and 230 µg/kg, respectively). Taking into consideration the average OTA contamination of coffee in Cameroon, Mounjouenpou et al. [64] estimated the daily intake of an adult of 70 kg at 0.065 ng/kg bw/day. Using the same deterministic approach, the maximum OTA daily intake that could be associated to black pepper (0.182 ng/kg bw/day) and white pepper (0.699 ng/kg bw/day) by adults of 60 kg was also found insignificant in comparison to the EFSA provisional tolerable daily intake value of 17 ng/kg bw/day [70]. Especially for maize, an exposure to FB_1 several-fold higher than the health-based guidance values (2 µg/kg bw/day) has been reported by Njumbe et al. [58]. A high risk was also noticed by these authors with the genotoxic carcinogen AFB_1 for which no tolerable daily intake (TDI) has been set, and the principle of "as low as reasonably achievable" (ALARA) applied. However, studying the maize dish called "maize-*fufu*", Abia et al. [61] noticed that the average daily exposures to AFB_1, FBs, DON and ZEN that could be associated were lower than 50% of maximum tolerable limit (MTL) for each respective mycotoxin [74].

Some studies have been carried out in Cameroon to assess the presence of mycotoxins in the human body. A recent study carried out by Chuisseu et al. [71] shows the presence of AFM_1 in 16 of the 42 breast milk samples they have collected, at a level ranging between 0.9 and 37 µg/kg feeding. A concentration of this toxin varying from 0.005 to 0.625 µg/L had already been reported by Tchana et al. [69] in 3 of the 62 breastfeeding milk samples they tested. These authors had also noticed that malnourished children suffering from kwashiorkor or marasmic kwashiorkor were showing a significantly higher

AFB_1 content in their urines compared to healthy children. The maximum values observed in these three groups were 2.84, 0.864 and 0.155 µg/L, respectively. Abia et al. [75] reported a higher occurrence of mycotoxins in urines from HIV positive people and estimated that their TDI should be reduced. In 2013, Njumbe et al. [76] noticed that the mean concentration of AFM_1 detected in the urine of the partially breastfed children (1.43 ng/mL) was significantly higher than those of the fully weaned children (0.282 ng/mL). They also observed that the DON and FB_1 content in these urine samples was significantly lower for females (0.71 and 0.01 µg/L, respectively) compared to males (3 and 0.59 µg/L, respectively).

5. CONCLUSION

The presence of mycotoxins in food may lead to severe health consequences for consumers. Even if the limited studies on the assessment of human exposure in Cameroon tend to show a limited health risk, it is important to note that some of the food samples analyzed presented mycotoxins contamination levels which were above the regulatory standards. This has a negative agro-economic impact on international trade for this country. Efforts should, therefore, be made by the government to educate producers on mitigation strategies (from farms to the final product), and populations on the risk associated with such contaminated products. More studies on exposure need to be done and should also focus on young children and the elder people who may be the most sensitive groups of the populations. The problem of multiple exposure/contamination of foods and subsequent synergistic/additive effects should also not be forgotten.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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