OCCURRENCE AND DIETARY RISK ASSESSMENT OF MYCOTOXINS IN MOST CONSUMED FOODS IN CAMEROON : EXPLORING CURRENT DATA TO UNDERSTAND FUTURES CHALLENGES

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◈ Introduction

Mycotoxins are naturally occurring toxins produced by certain moulds (fungi, mainly Aspergillus, Penicillium and Fusarium) that grow on a variety of different crops and foodstuffs (e.g. maize, peanut/groundnut, sorghum, millet, wheat, and rice, but also spices, dried fruits, apples, coffee beans and cocoa) under certain circumstances (e.g. warm and humid conditions) during harvesting, handling, storage, and processing. Preservation of food commodities in Cameroon is still of great concern in many communities. As recently highlighted by the narrative prevention project of the NGO NOODLES (Frazzoli and Mantovani, 2020) food agricultural and manufacturing practices currently adopted in Cameroon are often very suitable to mold proliferation and mycotoxins production. In Cameroon, few studies investigated the contamination of foodstuffs by mycotoxins. A large number of commodities including cereals (such as maize, sorghum, and rice) and derivatives (Njobeh et al. 2010; Djoulde, 2013) cassava, peanuts, beans, legumes, spices, and farmed fish have been found to be highly contaminated with mycotoxins (Njobeh et al. 2010 ; Ngoko et al. 2001 ; Tsafack et al. 2020). The presence of AFs and OTs has been reported in export products such as coffee and cocoa (Romani et al. 2000; Mounjouenpou et al. 2012; Nganou et al. 2014). Based on these preliminary data, this paper aims at providing an overview of the occurrence of mycotoxins in food commodities in Cameroon as well as a picture of the human dietary exposure in Cameroon, and possible risks scenarios derived from not adopting good practices.

◈ Methods

➢ **Eligibility criteria, data sources and searching strategies :**

Studies were included based on the following criteria: (i) Studies that reported food contamination by mycotoxins in Cameroon (ii) studies that report risk assessment related to mycotoxins (iii) articles that report mycotoxins health effects in animals and human. About 100 documents were selected, out of which around 56 papers contained data that could be used . Electronic databases : Pubmed, Science Direct, web of science, and Google Scholar. The following keywords were used: Mycotoxins, exposure, foods, Dietary exposure, risk assessment, total diet studies, estimated daily intake, health effects of mycotoxins, Cameroon. In this electronic database search, Boolean terms (AND/OR) were used to separate our keywords.

Dietary exposure and risk analysis

To obtain a distribution of human exposure levels by food, we used two sources of Cameroonian food consumption data: i) the Cameroonian Food Balance Sheet (FBS) from the FAO database (2018) and ii) data from the Total Diet Studies (TDSs) carried out in Cameroon (2008).

Consumption data from Food Balance Sheet (2018)

The per capita supply of each food item available for human consumption is obtained by dividing the food supply available for human consumption by the population actually consuming it. Data on per capita food supplies are expressed in terms of quantity and by applying appropriate food composition factors for all primary and processed products; they are provided also in terms of caloric value and protein and fat content (FAO, 2021).

Consumption data from Total Diet Studies (2008)

Total Diet Studies are used to assess long-term/chronic exposure to chemicals in the diet. In the TDS implemented in Cameroon by Gimou et al. (2008), the consumption data were obtained from the database of the Cameroonian Household Budget Survey. The amount of foods as purchased per adult equivalent in the households was then derived for an individual (Gimou et al. 2008).

Estimated Dietary Intake

Dietary exposure to mycotoxins in food commodities was calculated through EDI (Estimated Dietary Intake) as described below : **EDI (µg/kg bw/day) = mean conc. (µg/kg) * Food consumed (g/kg bw/day).** Assuming 60 kg as the average body weight (bw), the daily consumption per kg of bw was calculated. The health risk characterization of each mycotoxin was performed by dividing the EDI by the TDI (µg/kg bw/day) of the corresponding mycotoxin (when available), as indicated in the equation **%TDI = (EDI/TDI)*100**

◈ Mycotoxins in food commodities in Cameroon

➢ All the studies (Njobeh et al. 2010; Njumbe et al. 2014 ; Abia et al. 2013; Kana et al. 2013; Ingenbleek et al. 2019).) reported the presence of Aflatoxins (AFs, AFB1), Fumonisins (Fs, FB1), Deoxynivalenol (DON), Zearalenone (ZEN), Patulin, and Total citrinin in maize and in maize-derived products directly consumed by people (beer, porridge, *fufu*).

➢ AFs were observed with a high percentage of positive samples, with level depending on the agro-ecological zone (AEZ).

➢ Fumonisin B1 had been detected in number of food items (maize, maize based dishes, beans, traditional sorghum beer, spices, poultry feeds): the concentration varied enormously within and between food groups. Levels up to 26000 µg/kg have been found in maize (Ngoko et al. 2001; 2008).

➢ OTA is the most commonly OT found in foods -both raw and processed- and is the most dangerous in terms of toxicity. Ochratoxin contamination has been found in dried foods including nuts, beans, fruit and fish.

➢ The presence of OTA was detected in 10% of black pepper samples (1.2-1.9 µg/kg) and 40% of white pepper samples (1.8-4.9 µg/kg) collected from Yaoundé markets (Nguegwouo et al. 2017).

➢ It can infect wheat and barley crops, and it has also been found in poultry and pork (Mohamed et al. 2011) OTA is present in rice, coco beans, coffee (Arabica and Robusta), green coffee beans, fresh cassava and pepper with highest level found in Arabica coffee (124 µg/kg).

Table 1. Mycotoxins in Cameroonian food and their derivatives.

	Region (AEZ)	Mycotoxin	Mycotoxin (µg/kg) mean (min–max)	No. positive samples	References	Maximum Level in food	Hazard Index (QLmax/ML)
Maize grains	West (AEZ 3) North West (AEZ 3) Center (AEZ 5)	FB1 DON ZEN	(300–26000) (<100–1300) (<50–110)	18	Ngoko et al. 2001	ZEN: 60 µg/kg≠ 75 µg/kg** ZEN : 100 µg/kg EU ZEN: no Codex standard	FB1: 7 to 26 (ML) DON 1 to 6 (children) Zen: 2
	West (AEZ 3) North West (AEZ 3) Center (AEZ 5)	Fs DON ZEN	(50-26.000) (100-1300) (50-180)	18	Ngoko et al. 2008	FB1: 4000 µg/kg ≠ FB1: 1000 µg/kg ** (Krska et al., 2019) AFB1: 2000 µg/kg (Codex)	DON 1 to 6 (children) Zen: 3
	North West (AEZ 3) Center (AEZ 5) Littoral (AEZ 4)	FB1 ZEN DON AFs	3684 (37–24225) 69 (28–273) 59 (18–273)	26 31 29 22	Njobeh et al. 2010	AFB1: 10 µg/kg (CX/CF 19/13/15 March 2019) AFB1: 5 µg/kg EU AFs: 20 µg/kg ** US	FB1: 6 to 24 (ML) Zen: 4 DON (children): 1
	North West (AEZ 3)	FB1	508 (2-2313)	37	Abia et al. 2013	FDA AFs : 4 µg/kg EU	FB1(ML) : 0.5 to 2
	West (AEZ 3) North West (AEZ 3) Center (AEZ 5) North (AEZ 1)	AFs	1 (≤2- 42)	6	Kana et al. 2013	DON: 2000 µg/kg≠ DON: 750 µg/kg** DON (cereals based foods for children): 200 µg/kg	AFs : 4.2
	Littoral (AEZ 4) North (AEZ 1)	Total Citrinin	(5.7-6.5) (2.2-3.0)	NI	Ingenbleek et al. 2019	DON (wheat, maize): 1000 µg/kg	CIT : 0.0032 ZEN : 0.97
	Littoral (AEZ 4) North (AEZ 1)	ZEN	(7.6-97.0)	NI	Ingenbleek et al. 2019	CIT : 2000 µg/kg EU	to 1.61
	Littoral (AEZ 4) North (AEZ 1)	Fs	(64.4-71.6) (19.0-27.1)	NI	Ingenbleek et al. 2019		
Cassava	Littoral (AEZ 4)	OTA	(0.04-0.1)	NI	Ingenbleek et al. 2019	5 µg/kg (Codex)**	0.02
Cassava dry	Littoral (AEZ 4)	ZEN	7.6 (NI)	NI	Ingenbleek et al. 2019	EU (100 µg/kg)	0.08
Black pepper	Center (AEZ 5)	OTA	1.5 (1.2-1.9)	2	Nguegwouo et al. 2018	OT: 15 µg/kg	0.12
White pepper	Center (AEZ 5)	OTA	3.3 (1.8-4.9)	8	Nguegwouo et al. 2018		0.32

Table 2. Dietary exposure to mycotoxins through the consumption of contaminated foods in Cameroon. Expected intake compared to health guidance available. NE: Not Established

Foodstuff / Agro-ecological zone	Food consumption (mean, kg/person/day)		Contamination (µg/kg)			Estimated Daily Intake (µg/kg bw/day) (average bw = 60 kg)						Total Daily Intake (µg/kgbw/day) %TDI = (EDI/TDI)*100	
	FAO-FBS (2018)	TDS (2008)	Min	Mean	Max	Min		Mean		Max		TDI	%TDI-FBS (mean)
						FBS	TDS	FBS	TDS	FBS	TDS		
Maize	0.14	0.023	AFB1: 0.8	-	20	0.0018	0.003	-	-	0.046	0.007	NE	-
			FUM: 50	3684	26.000	0.12	0.02	8.6	1.4	60.6	9.96	2	430
			DON: 100	-	1300	14	2.3	-	-	182	29.9	1	1400
			ZEA: 27	69	334	0.063	0.01	0.16	0.026	0.78	0.13	0.5	32
Cassava	0.265	0.73	AFB1: 6	/	194	0.027	0.073	-	-	0.86	2.36	NE	-
Beans	0.0368	0.012	AFL: 0.2	2.4	6.2	0.0001	0.00004	14.72	0.0005	0.004	0.0012	NE	-
			FUM: 28	727	1351	0.017	0.0056	0.45	0.15	0.82	0.27	2	22.5
			ZEA: 27	48	187	0.017	0.005	0.029	0.01	0.11	0.04	0.5	5.8
			DON: 13	25	35	0.008	0.0026	0.015	0.005	0.021	0.007	1	1.5
Groundnuts	0.0293	0.021	AFB1: 47	-	210	0.023	0.016	-	-	0.1	0.07	NE	-
Spices (Njansang)	0.003	0.0012	AFs: -	0.63	-	-	-	0.000032	0.000013	-	-	NE	-
			FUM: -	78.62	-	-	-	0.0039	0.0016	-	-	2	0.195
			ZEA: -	7.84	-	-	-	0.00039	0.00016	-	-	0.5	0.078
			AFB1 : 1.81	8.81	15. 69	0.0001	0.000004	0.0007	0.0002	0.0012	0.0003	NE	-

Case description: the Penja pepper

- Penja pepper is among the best pepper in the world and much appreciated by top chefs. It is the first product to obtain a protected geographical indication (PGI) label in Sub Saharan Africa.

- To be recognized as Penja pepper one needs to cultivate it in a well described geographical zone that goes from the Moungo division (Manjo; Mbanga, Nlohé, Loum) to the south-west region (Tombel, Koupé manengouba).

- The characteristics of the soil and the microclimate of this geographical production area together with its organoleptic qualities, make Penja pepper an exceptional product.

- The sector currently has around 450 listed stakeholders, around 20% of which are women, located in five production areas. The identified producers cultivate approximately 420 hectares of pepper.

- Because of poor practices observed in certain farms, pepper production is at risks of many plants diseases (Figure 1) or plant death (Figure 2).

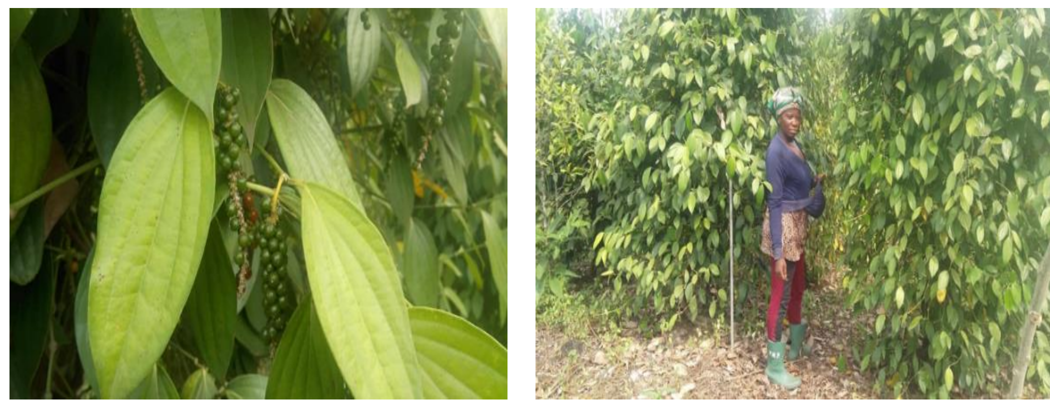

Figure 1. Harvesting of pepper in clothes; absence of protective equipment (Njombe, Cameroon).

Figure 3. Drying pepper with sunlight (Njombe, Cameroon).

Figure 2. Nematode facilitate gall diseases and fungi contamination; defoliated plant after fungi attack (Njombe, Cameroon).

Conclusion

Very few data exist on mycotoxin contamination in Cameroonian agricultural commodities and food items. Only 25 studies from 14 different authors have been published in the last decade. Based on the estimated distribution of human exposure levels by food, Maize and cassava are major source of exposure and should be prioritized, followed by beans and spices. The present study is aimed to contribute a national database of chemicals in foods towards national risk management of residues and contaminants in food.

The evidence reported here for mycotoxins is expected to motivate stricter and wider analytical control on the territory, to boost local research on these natural toxins in terms of food safety and nutrition, but also food security and associated economic impact, to further motivate the spreading of good practices and HACCP based approaches to avoid them (at the level of food producers, retailers, food transformers and vendors, and consumers), to improve efforts in national risk assessment and regulatory strategy.

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