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AFLATOXINS CONTAMINATION IN PROCESSED CASSAVA IN MALAWI AND ZAMBIA

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ABSTRACT

Strains of the *Aspergillus* fungi, especially *A. flavus* and *A. parasiticus*, primarily produce aflatoxins which are a major health concern to man and livestock because of their acute and chronic health effects. Aflatoxins pose the greatest risk to health in tropical Africa because of their widespread prevalence and high toxicity; carcinogenic (cause liver and esophageal cancer) effect, immune system suppressing and anti-nutritional contaminants in many food commodities and even cause death. Aflatoxins have also been reported to compromise vaccine efficacy in experimental animals. Due to the seriousness of aflatoxins, international agencies have restricted levels of aflatoxins to 20 ppb in food materials as the maximum permissible level in the United States and 4 ppb total aflatoxins and under 2 ppb aflatoxin B1 in Europe. These regulations directed at minimizing human exposure to aflatoxins results in severe economic loss to producers, processors and marketers of the contaminated crop. A study was conducted in Malawi and Zambia to assess the level of fungal and mycotoxins' contamination in commonly processed cassava products. A total of 92 and 88 samples of processed cassava products comprising *makaka*, flour, *kanyakaska*, *kadonoska*, scrapes and grates were collected in the rainy season of 2008 and 2009 in Malawi, respectively. Further, 22 samples of processed cassava products comprising dried cassava chips and flour were collected in the rainy season of 2009 in Zambia. The samples were analyzed for fungal and aflatoxins B1, B2, G1 and G2 contamination using the Romer mini-column method and the VICAM AflaTest immunoaffinity fluorometric method. None of the samples in 2008 were contaminated with aflatoxins. Similar results were obtained in 2009 with almost all the samples in Malawi and Zambia having aflatoxin levels much lower ($\leq$2.0 µg/kg in Malawi and <4.2 µg/kg in Zambia) than the Codex Alimentarius Commission (CAC) maximum permissible level of aflatoxins of 10.0 µg/kg, implying that the cassava products analyzed were safe for human consumption. However, further studies are needed to cover a larger sample size over a period of a year to represent all seasons in the cassava producing and consuming areas and conclusively make certain the safety of these products for human consumption.

Key words: Cassava, consumption, aflatoxin, food, safety

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a major staple food crop across tropical sub-Saharan Africa [1]. In Malawi and Zambia it is the second most important staple (after maize) nourishing over 30% of the population. Besides being an important food, cassava has huge potential for industrial application in the plywood, confectionery, feed and pharmaceutical sectors [2, 3, 4].

As cassava is highly perishable, it is often processed into dry forms such as *kadonoska*[1], *kanyakaska*[2], *makaka*[3], fermented and unfermented flour to increase shelf life. *Kadonoska, kanyakaska and makaka* are processed into flour for *nsima*[4] *(nshima* in Zambia) or confectioneries or stored for later use. However, poor drying during processing or storage, especially during the rainy season, often results in contamination by fungi such as *Aspergillus, Fusarium* and *Penicillium.* This is because rain/drizzles may fall on the drying products and predispose them to mould growth as drying is often done in the open and unprotected areas.

Many of the *Aspergillus* fungi, especially *A. flavus* and *A. parasiticus*, produce aflatoxins which are a major health concern to man and livestock because of their acute and chronic health effects. Aflatoxins pose the greatest risk to health in tropical Africa because of their widespread prevalence and high toxicity [5] and have been known to be carcinogenic (cause liver and esophageal cancer), immune system suppressing [6, 7] and anti-nutritional contaminants in many food commodities [8] and even to cause death. In addition, they have been reported to compromise vaccine efficacy in experimental animals [9, 10]. Aflatoxins' role in reduction of child growth and development has also been reported [11]. Since chronic diseases in developing countries are underreported, the actual health impacts of aflatoxins may be higher than what is known.

Studies in Uganda, Kenya, and Democratic Republic of Congo, Tanzania, Thailand, Brazil and Indonesia have shown that processed cassava can be contaminated with aflatoxins to various levels [3, 5, 12, 13, 14, 15]. However, in the Southern Africa region, there is little information on the level of aflatoxin contamination in processed cassava that would enable consumers to take precautionary measures against consumption of such products. The present paper reports on the results of a survey appraisal that was conducted in Malawi and Zambia to assess the aflatoxin situation of locally processed cassava products.

[1] Dried fermented cassava pulp molded into small balls with a depression at the center to facilitate drying
[2] Dried fermented cassava pulp broken into small pieces for ease of drying
[3] Dried cassava chips, usually unfermented
[4] Thick starchy porridge made from maize, cassava, or other starch flour

MATERIALS AND METHODS

The study was conducted during the rainy season (November to May) of 2008 and 2009 in Malawi and the rainy season of 2009 in Zambia. The rainy season was targeted because mould growth during processing or storage is a problem during this period due to high humidity [16].

In Malawi, samples of processed cassava products, each weighing 1 kg, were randomly collected from households in main cassava growing districts of Mulanje, Chiradzulu (confectionery processing warehouse), Zomba and Mangochi in the southern region; Nkhotakota and Kasungu in the central region and Rumphi, Mzimba (Mzuzu market) and Nkhata Bay in the northern region. Some samples were collected purposefully from main processing units in Lilongwe and Blantyre. A total of 92 samples comprising *makaka*, *kanyakaska*, *kadonoska*, fermented and unfermented flour, scrapes and grates were collected in February 2008 and another 88 samples comprising *makaka*, fermented flours, *kanyakaska* and *kadonoska* were collected in March 2009. More samples (>80%) were collected in Nkhata Bay and Nkhotakota because of the abundance of the processed products in the area.

The 2008 samples were analyzed for fungal and aflatoxins B1, B2, G1 and G2 contamination using the Romer mini-column method. Due to the lower sensitivity of this method (limit of detection of 2 µg/kg) the samples that were collected in 2009 were analyzed using the VICAM AflaTest® immunoaffinity fluorometric method [17] (limit of detection of 1 µg/kg) that quantifies total aflatoxin (B1+B2+G1+G2) concentrations using AflaTest® Fluorometer Series-4.

In Zambia, a total of 22 samples, 21 of dried chips and 1 of flour, each weighing 1 kg, were collected in April 2009 from farmers and market places in Mansa and Mwense districts in Luapula province, Kasama and Luwingu districts in Northern province, Kabompo and Solwezi districts in Northwestern province, Kaoma and Lukulu districts in Western province and Ndola district in Copperbelt province. The districts were purposefully selected as they were potential areas for cassava production, processing and utilization. However, the collection of samples within each district targeted areas where processed cassava was likely to be found such as homes and market places. The samples collected were from the previous dry season's harvest hence were about a year old. Many farmers do not keep their processed cassava for that long hence the limited samples collected in Zambia. The samples were analyzed for total aflatoxins using the VICAM AflaTest® immunoaffinity fluorometric method [17].

RESULTS

None of the cassava samples collected in 2008 in Malawi were contaminated with aflatoxins B1, B2, G1 and G2 as the concentrations were less than 2 µg/kg (Table 1). According to the method used in the analysis (Romer mini-column) the limit of detection was 2 µg/kg and samples which tested less than this value were taken as

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negative. The only contamination detected, however, was in the unfermented samples (scrapes, *makaka* and unfermented flour) but this was due to *Microphomina phaseoli* fungus and not aflatoxins B1, B2, G1 or G2. This indicates that the samples were free from aflatoxins contamination and hence fit for human consumption.

Similar results were obtained in 2009. Only 2 (2%) of the 88 samples collected in Malawi were contaminated with aflatoxins but in both cases the concentration was <2 µg/kg (Table 2). Similarly, in Zambia 2 (9.1%) of the 22 samples collected were detected with aflatoxins, one with 4.2 µg/kg and the other with 16.0 µg/kg (Table 3).

DISCUSSION

In general, the levels of contamination in this study were much lower than the Codex Alimentarius Commission (CAC) maximum permissible level of aflatoxins of 10 µg/kg in ready to eat foods [18] except for one sample from Zambia that had a higher level (16.0 µg/kg) than this. The results indicate that very little aflatoxin contamination takes place in processed cassava in the two countries which implies that farmers are consuming safe products free of aflatoxins. However, the absence of aflatoxins in mouldy samples suggests possible prevalence of other mycotoxins that were not tested in this study. Low aflatoxins incidences in cassava have also been reported elsewhere. In Tanzania, 18 samples of cassava products processed by smallholder farmers using sun drying and solid state fermentation showed no aflatoxins contamination [19]. Similar results were reported in Ghana in 2 samples of *kokonte*[5][16]. Also, a report on the assessment of cassava chips in Benin revealed no aflatoxins or fumonisin B1 contamination [20] and no aflatoxins contaminations were found in 14 samples of dark and moldy cassava in Mozambique and in 10 samples of cassava flour in Uganda [21]. Considering that surveys of other food matrices in Malawi have shown high concentrations of aflatoxins [22, 23, 24, 25, 26], the low aflatoxin contamination in the cassava products supports earlier conclusion that cassava does not provide a good substrate for aflatoxin production [27]. In contrast, in Uganda relatively high incidences (30%) of aflatoxin contamination were reported even though the levels were low (<4.5 µg/kg) [3] while in the Philippines even higher incidences (100%) and contamination (mean of 467.5 µg/kg) in 142 samples of processed cassava products were reported [28] which was much higher than the 2.0% in Malawi and 9.1% in Zambia, respectively, found in this study.

The results of this study are contrary to findings from other studies [5, 13, 28] despite the fact that only locally processed products of different sizes were sampled. All the *makaka* (chips) that were sampled were of large size and the sampling was done during the rainy period both in Malawi and Zambia. While comparing the safety of traditionally processed cassava chips with those processed using improved chipping machine in Uganda, higher aflatoxins levels in traditionally processed (15 µg/kg) than in improved chipping machine processed (0.07 µg/kg) cassava chips were reported [13]. The levels in traditionally processed chips were also higher than the normative

[5] Fermented dried cassava product

level of 10 µg/kg[28]. Another study [5] reported that levels of aflatoxin B1 varied from 0.3 to 4.4 µg/kg in cassava chips and flour and from 0.1 to 13.0 µg/kg in stored cassava samples, with relatively high levels of contamination in cassava stored for 4 months. This corroborated with another study in the same year [13] which reported that humidity, which is prerequisite for aflatoxin contamination, increases with an increase in chip size, insect damage and length of storage period. As high humidity is a pre-requisite for aflatoxin contamination, it is unlikely that there can be high contamination during the dry season (May to November) when the humidity is low and the drying is faster due to less cloudy conditions.

CONCLUSION

The study has shown that there is little aflatoxins contamination in the processed cassava products in Malawi and Zambia. This implies that the people are consuming safe cassava products free from aflatoxins' contamination. However, as the survey did not cover in detail all conditions that favour aflatoxin contamination, it could be also possible that other mycotoxins that were not tested may be prevalent. There is need, therefore, to conduct further intensive studies on other mycotoxins in cassava products being consumed in Malawi and Zambia. Meanwhile, it is recommended that farmers/consumers should ensure proper drying and storage of their cassava products to minimize mould growth and avoid consumption of mycotoxin contaminated products.

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Table 1: Aflatoxins levels in processed cassava products collected in February/March 2008 in Malawi

Type of sample	Quality of sample	No. of samples	Aflatoxins concentration (μg /kg)
Heap fermented chips	Mould free	15	<2
Heap fermented chips	Moldy	6	<2
Kadonoska	Mould free	2	<2
Kanyakaska	Moldy	1	<2
Kanyakaska	Weeviled	3	<2
Kanyakaska	Mould free	5	<2
Kondowole	Mould free	4	<2
Kondowole	Moldy	1	<2
Makaka	Mould free	7	<2
Makaka	Moldy	5	<2
Makaka	Weeviled	12	<2
Scrapes	Mould free	2	<2
Scrapes	Moldy	1	<2
Unfermented flour	Mould free	1	<2
Unfermented flour	Moldy	1	<2
Total		66	

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Table 2: Aflatoxins levels in processed cassava products collected in March 2009 in Malawi

District	Number of samples collected and source				
	Farmer	Shop /vendor	Commercial processor	Total	Aflatoxin content (μg /kg)
Nkhata Bay	32	5	0	37	<1.0
Nkhotakota	28	8	0	29	<1.0
Zomba	1	1	2	4	<1.0
Chiladzulu	0	3	2	5	<1.0
Mulanje	0	2	0	2	<1.0
Lilongwe	0	0	2	2	<1.0
Total	**61**	**19**	**6**	**79**	
Nkhata Bay	1	0	0	1	>1.0–2.0
Nkhotakota	0	1	0	1	>1.0–2.0
Total	**1**	**1**	**0**	**2**	

Table 3: Aflatoxins levels in processed cassava products collected in April 2009 in Zambia

Type of Product	Source	Town	Village	Aflatoxins content (μg /kg)
Dried chips	Farmer	Mansa	Nyense	<1.0
Dried chips	Farmer	Mansa	Samba	<1.0
Dried chips	Farmer	Mansa	Matanda	<1.0
Dried chips	Farmer	Mamba	-	<1.0
Dried chips	Farmer	Kabompo	-	<1.0
Dried chips	Farmer	Kabompo	Kaivu	<1.0
Dried chips	Farmer	Lukulu	-	<1.0
Dried chips	Farmer	Mwense	Chipokotola	<1.0
Dried chips	Farmer	Mwense	-	<1.0
Dried chips	Farmer	Mwense	Chipokotola	<1.0
Dried chips	Farmer	Kaoma	Nginda	<1.0
Dried chips	Farmer	Kaoma	-	<1.0
Dried chips	Farmer	Kaoma	-	<1.0
Dried chips	Farmer	Solwezi	-	<1.0
Dried chips	Farmer	Isoka	-	<1.0
Dried chips	Farmer	Kasama	Dairy Scheme	<1.0
Dried chips	Farmer	Kasama	Nsando	
Dried chips	Farmer	Mongu	-	<1.0
Dried chips	Farmer	Luwingu	Museya	<1.0
Flour	Farmer	Ndola	Masala Market	<1.0
Dried chips	Farmer	Kasama	Chibo	4.20
Dried chips	Farmer		Kajanga	16.0

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