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Co-contamination of Nigerian Cocoa and Cocoa-Based Powder Beverages Destined for Human Consumption by Mycotoxins

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ABSTRACT A total of sixty-four (64) samples consisting of cocoa (processed and non-processed) and cocoa based powder beverages were collected from fields, stores and markets in different areas in south-western Nigeria and screened for the five major mycotoxins- aflatoxins (AFs), ochratoxin A (OTA), zearalenone (ZEA), deoxynivalenol (DON) and fumonisins (FBs). Mycotoxins analyses were done after extraction by high performance liquid chromatography (HPLC), which showed contamination of the food commodities by major mycotoxins (AFs, OTA, DON, ZEA and FBs) at different incidences and concentration ranges. Results from HPLC analysis showed concentration of AFs, OTA, fumonisin B_1 (FB_1), fumonisin B_2 (FB_2), ZEA and DON up to 16.01µg/kg, 884.8µg/kg, 440µg/kg, 20.2µg/kg, 2364.7µg/kg and 8.5µg/kg respectively in the different food samples analysed. The contamination and co-contamination of these food commodities by some of these mycotoxins at concentrations above the different set regulatory limits by the EU and other countries is of concern with attendant health risks, particularly for Nigerians who consume these contaminated cocoa and cocoa products as part of their diets.

I. INTRODUCTION

Mycotoxins commonly occur in a wide range of fungal contaminated food commodities (V Kumar et al. 2008) of which cocoa is one of them (Copetti et al. 2010, 2011). Cocoa is predominantly cultivated in West and Central Africa regions where temperatures are high and humid thereby encouraging the growth of fungal populations and subsequent production of mycotoxins. *Aspergillus* species and their metabolites are common contaminants of cocoa and cocoa based products especially from these regions of Africa (Oyetunji 2006; Sanchez-Hervas 2008) particularly in Nigeria (Oyetunji 2006). Cocoa is one of the major food commodities exported from Nigeria and is an important revenue source for the country with Nigeria being the fourth largest producer of cocoa in the world behind Cote d'Ivoire, Ghana and Indonesia (Cocoa growing). These raw cocoa produces are usually used in the production of other finished foods such as biscuits, coffee, chocolate, cocoa powder and sweets (Sanchez-Hervas 2008) within the country and outside. Cocoa is also consumed in various forms by the populace of Nigeria such cocoa beverages, biscuits, and chocolate drinks.

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Mycotoxins, which are secondary metabolites produced by certain fungal group (filamentous fungi) under certain environmental conditions, have continued to be a reason for concern in food safety globally (Jouany 2007; Krska et al. 2007; Wagacha and Muthomi 2008). The reason for the increasing concern can be attributed to the toxigenic, mutagenic, teratogenic, genotoxic and carcinogenic properties of these chemical substances, when ingested or inhaled by humans and animals (Richard 2007). Out of over 300 mycotoxins reported worldwide (Brasel and Hussein 2001), aflatoxins, ochratoxins, fumonisins, zearalenone and the trichothecenes are known to be of greater interests as these mycotoxins do not only occur commonly in the environment but have adverse health effects when exposed to them in large doses and over a long period of time (Richard 2007).

In this study, the occurrence of mycotoxins in cocoa seeds, processed cocoa and cocoa based powder beverage samples from Nigeria was determined in order to assess the potential health dangers for consumers, in particular population groups within Nigeria.

II. METHODOLOGY

2.1 Chemicals

All chemicals and reagents used in this study were at least of analytical grade, unless other-

wise specified and purchased from Sigma-Aldrich chemical company.

2.2 Sampling

Sixty-four samples (about 200g) of cocoa (39) and cocoa-based powder beverages (25) were collected from different fields, stores and market places in south western Nigeria by thorough mixing. Cocoa samples consisted of cocoa seeds (collected from the growing fields and stores) and blended processed cocoa (collected from markets). Cocoa-based beverage samples were collected from various markets. All samples collected were destined for human consumption and were visibly in sound condition.

2.3 Sample Preparation

Representative samples were collected in plastic bags and sealed for transportation to the Food, Environment and Health Research laboratory, University of Johannesburg, South Africa following all necessary custom duty protocols.. All cocoa seed samples were ground using a laboratory mill (IKA M20, Merck, Darmstadt, Germany) and collected in plastic bags for analysis. These samples were screened for mycotoxin contamination implementing various analytical methods.

2.4 Mycotoxin Standards

Aflatoxin B_1 (AFB_1), aflatoxin B_2 (AFB_2), aflatoxin G_1 (AFG_1), aflatoxin G_2 (AFG_2), ochratoxin A (OTA), zearalenone (ZEA) and deoxynivalenol (DON) were obtained from Sigma Aldrich Co., South Africa. Whereas, FB_1 and FB_2, standards were obtained from the Programme on Mycotoxins and Experimental Carcinogenesis (PROMEC) MRC Unit, South Africa. Standard solutions of AFs, OTA, ZEA and DON were prepared by dissolving the pure standards in HPLC grade acetonitrile to give concentrations 1µg/ml each for OTA, AFs, ZEA, and 5µg/ml for DON. Standard solutions of the fumonisins were prepared by dissolving in HPLC grade methanol to give concentrations of 1µg/ml each for FB_1 and FB_2.

2.5. Mycotoxin Extraction and Clean-up from Food Samples

The method of multi-mycotoxin extraction procedure devised by D.S. Patterson and B.A. Roberts (1979) was implored for extraction and clean-up of ZEA, AFs, OTA and DON, Strong anion exchange (SAX) columns were used for FUM extraction and clean-up following the method of Shephard and Sewram (2004) with some modifications. Also, immuno-affinity columns were used for extraction and clean-up of some of the mycotoxins (aflatoxins, fumonisins and Ochratoxin A) following the manufacturer's instruction manual (VICAM Ltd. Watertown, USA) for confirmation of results obtained from multi-mycotoxin extraction procedure and SAX column extraction procedure.

2.5.1 Multi-mycotoxin Extraction and Clean-up

Twenty five grams of milled samples were weighed into 250ml conical flasks containing 100ml of acetonitrile/4% potassium chloride (KCL) (90/10 v/v) and placed on a shaker for one hour to homogenise. After shaking, samples were filtered using a Whatmann no. 1 filter paper and the filtrate collected in a beaker. The filtrate was then transferred to a 250 ml separating funnels for further clean-up and extraction. The filtrate was de-fatted twice using equal volumes of isooctane after which, 30ml of saturated $NaHCO_3$ made up to 50ml with distilled water was added to the aqueous filtrate to separate the neutral and acid parts of the filtrate. 50ml of DCM was then added to the aqueous filtrate, shaken slightly and the bottom part extracted through a bed of anhydrous sodium sulphate bed (5-10g) into a round bottom flask retaining the aqueous part in the separating funnel and the sodium sulphate bed. Three portions of 25ml DCM was further added to the aqueous extract and the bottom part (DCM) extracted through the sodium sulphate bed into the round bottom flask containing the previously collected DCM retaining the aqueous extract in the separating funnel. The total DCM solution collected was then evaporated using a rotary vacuum evaporator (Buchi Laboratory-Techniques Ltd., Flawil, Switzerland). The dry extract was reconstituted with 2ml acetonitrile and using a pipette, transferred to 25cm dialysis tubing previously soaked in distilled water for more than one hour before use. The dialysis tubing is knotted at the bottom twice to prevent any leaks and the reconstituted extract in acetonitrile transferred to the dialysis tubing. 1ml of acetonitrile was added to the round

bottom flask to further dilute any remaining extract and transferred to the dialysis tubing. The dialysis tubing was knotted at the top, put into a boiling test tube and 50ml of 30%acetone added to the test tube, which was then sealed with a foil and rubber band or parafilm. The test tube was then placed on a shaker to shake overnight to dialyze. After dialysis, the extract was put into a separating funnel and extracted three times with 25ml DCM and the lower part (DCM) was passed through an anhydrous sodium sulphate bed into a round bottom flask. The DCM was evaporated using the rotary vacuum evaporator and the dried extract reconstituted with 2ml of DCM and using a sterile Pasteur pipette transferred to a 1 dram screw cap vial. 1 ml of DCM was used to dilute any remaining extract in the round bottom flask, pipetted into the same 1 dram screw cap vial and evaporated under a stream of nitrogen gas at 60°C. This constituted the Neutral Fraction (N.F) of the extract.

The previously remaining aqueous extract in the separating funnel was acidified with 50ml 1M Na_2SO_4 and extracted with three 25ml portions of DCM through an anhydrous sodium sulphate bed into a round bottom flask. The DCM was dried using the rotary vacuum evaporator and the dry extract reconstituted with DCM and pipette using a sterile pipette transferred to 1 dram screw cap vial. 1ml of DCM was added to dissolve any remaining extract, transferred to the same vial and evaporated at 60°C under a stream of nitrogen gas. This part constituted the Acid Fraction (A.F) of the extract.

Both fractions of extracts (acid and neutral) were stored at 4°C in refrigerator until analysis by HPLC.

2.5.2 Fumonisins Extraction and Clean-up

The extraction of fumonisins required a different method because of the solubility of fumonisins in lower alcohols especially methanol and water. Ten grams of milled samples were mixed in 100ml methanol/water (70/30, v/v) and shaken for one hour. Extract was filtered through Whatmann no. 1 filtered paper. The pH of filtered samples extract (2ml) was adjusted to between 5.9 and 6.5 with 1M acetic acid or 1M sodium hydroxide and extracts further diluted with 4ml methanol-water (70/30, v/v). Columns were pre-conditioned with 5ml methanol and washed with 5ml methanol-water (70/30, v/v). Diluted sample extracts were then loaded onto the SAX columns assembled on a Waters vacuum manifold from Milford Massachusetts, USA fitted to an air compressor. Flow rate was maintained at 1 ml per minute. After diluted sample extracts had run through, columns were further washed with 5ml methanol-water (70/30, v/v) and 5ml methanol. Fumonisins were then eluted with 5ml methanol-acetic acid (99/1, v/v) and the elute evaporated to dryness at 50°C under a stream of nitrogen. The dry extract was stored at 4°C until required for HPLC analysis.

2.5.3 Immuno-affinity (VICAM) Columns Extraction and Clean-up

As was stated earlier, clean-up and extraction using immune-affinity columns was done following the procedure of the manufacturers (VICAM Ltd. Watertown, USA). Due to economic reasons, some mycotoxins were not screened for using this method. Only mycotoxins OTA, AFs and FUMs were analysed. Since different food samples were screened, different solvents were used for the procedure including methanol/water (80/20), methanol/1% sodium bicarbonate (70/30) and 1% sodium bicarbonate solution. The extracts were applied to the columns and the mycotoxins acted as antigens binding to the antibodies present in the column. The mycotoxins were then eluted with an eluting solution (HPLC grade methanol) which was passed through the column while concentration of the different mycotoxins was determined using the HPLC apparatus.

2.6. High Performance Liquid Chromatography Analyses of Extracts

High Performance Liquid Chromatography analyses was carried out using a HPLC Spectra Physics SCM400 SYSTEM (Waters, Milford, MA, USA), Shimadzu Corporation (Kyoto, Japan) LC-20AB liquid chromatograph equipped with CBM-20A communication bus module, LC-20AB degasser, CTO-20A column oven, Nova-Pak 4mm C18 reversed phase analytical column (250×4.6 mm, 5μm), SIL-20A auto sampler, RF-10AxL fluorescence detector, RID-10A refractive index detector and SPD-M20A photodiode array detector linked to LC solutions version 1.22 Software Release.

Dry extracts from multi-mycotoxin extraction procedure and immuno-affinity columns were re-

dissolved in 500ul of acetonitrile for AFs, OTA, DON and ZEA analysis, transferred into blue cap HPLC vials for analysis. For FBs, extracts were dissolved in 1ml methanol and 50µl transferred into a HPLC vial mixed with 250µl of o-pthaldialdehyde (OPA) reagent prepared by dissolving 40 mg of OPA in 1 ml CH_3OH and diluted with 5 ml 0.1M sodium tetraborate ($Na_2B_2O_4$) and 50µl mercapthoethanol. Samples were run at 1ml per minute (min^{-1}) recording retention times against standards of known concentrations. The analysis of the different mycotoxins involved the use of specific mobile phases and methods of detection following the methods of Abdulkadar et al. (2004) and Reiter et al. (2009).

2.7 Recoveries

To confirm the efficacy of the methods implemented for extraction of mycotoxins from samples, different concentrations of mycotoxins were used to spike negative samples in triplicates and extracted using the methods of multimycotoxin extraction, SAX columns and immuno-affinity columns. 100µg/ml, 50µg/ml, 100µg/ml, 50µg/ml and 50µg/ml of AFs, OTA, FBs, ZEA, and DON were respectively spiked on samples and mixed thoroughly before extraction using the different methods. Extracts were analyzed using the HPLC apparatus.

2.8 Statistical analysis

A one-way analysis of variance (ANOVA) was performed to derive mean values, which were compared by least significant differences using all pairwise multiple comparison procedures (Holm-Sidak method) and further, a linear regression analysis was done on SigmaStat 3.5 for Windows (Systat Inc 2006a). Data was further graphically represented using SigmaPlot for Windows Version 10.0 (Systat Inc, 2006b). Mean values among treatment groups were deemed to be different if the level of probability was <0.05.

III. RESULTS

3.1 High Performance Liquid Chromatography Results

Mycotoxin analysis and quantification by HPLC from multi-mycotoxin procedure and SAX columns showed incidences of the different mycotoxins in all extracts of food samples at different concentration ranges as indicated in Tables 1, 2 and 3. Extracts from cocoa seeds, processed cocoa and cocoa-based powder beverages showed varying incidences of AFs, OTA, FBs, ZEA and DON. In cocoa seed extracts, incidences of 88.2%, 88.2%, 0%, 23.5%, 100% and 0% were detected for AFs, OTA, DON, ZEA, FB_1 and FB_2 respectively. Extracts from processed cocoa samples showed percentage incidence rates of 72.7%, 72.7%, 59.1%, 68.2%, 86.4% and 0% detected for AFs, OTA, DON, ZEA, FB_1 and FB_2 respectively, whereas, incidences of 44%, 56%, 32%, 72%, 84% and 4% were detected for AFs, OTA, DON, ZEA, FB_1 and FB_2 respectively in cocoa-based powder beverage extracts. Concentration ranges in µg/kg of 0.03-4.97, 0.7-525.4, 18.7-206 and 24.2-83.6 for AFs, OTA, FB_1 and ZEA respectively was determined in cocoa seed samples; whereas, concentrations of 0.59-16.01, 0.3-884.8, 7.6-440, 10.4-531.9 and 0.2-8.5 in µg/kg for AFs, OTA, FB_1, ZEA and DON respectively was measured in processed cocoa samples. Concentration ranges in µg/kg for cocoa-based samples for AFs, OTA, FB_1, FB_2, ZEA and DON were 0.06-9.8, 0.3-72.6, 5.1-208.7, n.d-20.2, 34.4-2364.7 and 0.1-7.6 respectively.

Table 1: Analyses of mycotoxins in cocoa seed samples as determined by high performance liquid chromatography

Mycotoxins	*% incidence*	*Range*	*Mean**	*Std. dev.*
Aflatoxins	88.2	0.03-4.97	1.12	1.70
Ochratoxin A	88.2	0.7-525.4	88.8	168.7
Fumonisin B_1	100	18.7-206	123.6	61.1
Fumonisin B_2	n.d	n.d	n.d	n.d
Zearalenone	23.5	24.2-83.6	49.9	25.5
Deoxynivalenol	n.d	n.d	n.d	n.d

Mean*- mean of positive samples. Concentrations of AFs, DON, FBs, OTA and ZEA in samples are in µg/kg. % incidence- no. of positive samples in percentage. Std. Dev. – standard deviation.

Results for the extracts of selected samples using immuno-affinity columns also showed varying mycotoxin concentration ranges, which were much higher in comparison to concentration of mycotoxins from the multi-mycotoxin procedure and SAX columns. This could be attributed to the high specificity of the immune-affinity columns whereby the reaction involved

Table 2: Analyses of mycotoxins in processed cocoa samples as determined by high performance liquid chromatography

Mycotoxins	*% incidence*	*Range*	*Mean**	*Std. dev.*
Aflatoxins	72.7	0.59-16.01	6.05	4.98
Ochratoxin A	72.7	0.3-884.8	80.8	185.5
Fumonisin B_1	86.4	7.6-440	238.2	167.2
Fumonisin B_2	n.d	n.d	n.d	n.d
Zearalenone	68.2	10.4-531.9	208.2	156.1
Deoxynivalenol	59.1	0.2-8.5	3.3	2.4

Mean*- mean of positive samples. Concentrations of AFs, DON, FBs, OTA and ZEA in samples are in µg/kg. % incidence- no. of positive samples in percentage. Std. Dev. - Standard deviation

Table 3: High performance liquid chromatography detection in cocoa-based powder beverage samples

Mycotoxins	*% incidence*	*Range*	*Mean**	*Std. dev.*
Aflatoxins	44	0.06-9.8	2.99	2.63
Ochratoxin A	56	0.3-72.6	14.0	17.0
Fumonisin B_1	84	5.1-208.7	45.2	54.3
Fumonisin B_2	4	n.d- 20.2	20.2	4.0
Zearalenone	72	34.4-2364.7	998.8	724.4
Deoxynivalenol	32	0.1-7.6	2.2	1.8

antigen-antibody reaction. Tables 4, 5 and 6 show the comparison of mycotoxin concentrations.

Table 4: High performance liquid chromatography detection of aflatoxins from multi-mycotoxin and VICAM extraction

Samples	*Multi-mycotoxin (µg/kg)*	*VICAM (µg/kg)*
Cocoa-3	0	0
Cocoa-6	0.24	0.37
Cocoa-2	4.97	4.62
Cocoa-31	0	0
Cocoa-32	16.01	17.12
Cocoa-25	7.07	6.2
Cocoa beverage-19	0	0
Cocoa beverage-25	9.38	18.15
Cocoa beverage-14	3.30	4.75
Cocoa beverage-9	0	0
Cocoa beverage-20	1.58	1.23
Cocoa beverage-11	0	0

3.2 Statistical Analysis

Statistical analysis of results from mycotoxin analysis of cocoa and cocoa-based powder beverage samples showed a significant difference of ($P<0.001$) for all samples in groups with five (5) degrees of freedom. Pairwise multiple comparison of individual mycotoxins analysed against the other indicated YES for $P<0.05$ for a majority of samples analyzed. Also, statistical analysis to determine the degree of correlation between the concentration of mycotoxins detected from multi-mycotoxin extraction and SAX column extraction in relation to that detected from VICAM extraction was carried out and is indicated in Table 7.

Table 5: High performance liquid chromatography detection of ochratoxin A from multi-mycotoxin and VICAM extraction

Samples	*Multi-mycotoxin (µg/kg)*	*VICAM (µg/kg)*
Cocoa-36	0	0
Cocoa-5	0	0
Cocoa-11	8.6	10.7
Cocoa-9	0	0
Cocoa-1	52.1	64.0
Cocoa-21	56.3	59.3
Cocoa-19	48.9	61.8
Cocoa-17	66.8	72.1
Cocoa-16	43.7	49.0
Cocoa-29	884.8	946.7
Cocoa-26	0	0
Cocoa beverage-18	29.7	36.8
Cocoa beverage-10	0	0
Cocoa beverage-4	72.6	68.2
Cocoa beverage-3	0	0
Cocoa beverage-5	45.4	56.1
Cocoa beverage-15	9.8	7.6
Cocoa beverage-13	0	0

Table 6: High performance liquid chromatography detection of fumonisin B_1 and fumonisin B_2 from Strong Anion Exchange columns and VICAM extraction

	SAX columns (µg/kg)		*VICAM (µg/kg)*	
Samples	*FB_1*	*FB_2*	*FB_1*	*FB_2*
Cocoa-1	109.6	0	135.3	0
Cocoa-5	92.1	0	110.0	0
Cocoa-6	20.7	0	48.3	0
Cocoa-7	206.0	0	264.6	0
Cocoa-15	80.9	0	92.7	0
Cocoa-26	0	0	0	0
Cocoa-33	440.0	0	672.8	0
Cocoa beverage-2	5.1	0	7.7	0
Cocoa beverge-10	21.7	0	32.8	0
Cocoa beverage-14	54.0	0	59.0	0
Cocoa beverage-19	23.4	0	48.5	0
Cocoa beverage-23	208.7	20.2	238.9	29.0
Cocoa beverage-25	0	0	0	0

3.3 Recoveries

Recoveries of up to 89% ± 1.1% and 82% ± 2.1% were recorded for mycotoxins extracted from cocoa and cocoa-based powder samples respectively via multi-mycotoxin procedure

Table 7: Correlation co-efficient (r) for mycotoxins detected from multi-mycotoxin procedure and SAX columns in comparison with VICAM extraction

Food samples	*Correlation co-efficient (r)*			
	AFs	*OTA*	*FB_1*	*FB_2*
Cocoa	0.996	1.0	0.991	-
Cocoa beverage	0.992	0.984	0.990	-

whereas 79% ± 2.1% and 65% ± 1.0% of recovery rates were recorded for fumonisin extraction using SAX columns from cocoa and cocoa-based samples respectively. Percentage recoveries using immune-affinity columns were found to be 93% ± 1.0% and 90% ± 2.0% for mycotoxins extracted from cocoa and cocoa based powder samples respectively.

IV. DISCUSSION

4.1 Mycotoxin Contamination of Samples

Mycotoxin screening by HPLC following the different methods of extraction showed contamination of both cocoa seeds, processed cocoa and cocoa-based powder beverages by the major mycotoxins analysed in this study at different concentrations with OTA occurring at highest concentration.

Data showed an increased concentration of the mycotoxins in processed cocoa samples in comparison to raw cocoa samples and subsequent reduction in cocoa-based beverages. This increase in mycotoxins contamination in processed cocoa samples could be attributed to the improper post- harvest practices while the reduction in mycotoxins concentration in cocoa-based powder beverages could be attributed to the production processes (Wagacha and Muthomi 2008). Concentrations of OTA, ZEA and AFs were above the set regulatory limits in some of the samples with OTA values way above the set limits of 3-50ppb. Other mycotoxins- FBs and DON had concentrations below the set regulatory limits.

Ochratoxin A, which is produced by *Aspergillus ochraceus*, *Penicillium viridicatum* and in some cases by *Aspergillus niger* and *Aspergillus carbonarius* (Bragulat et al. 2001) was detected in all food samples analyzed, though at different concentrations. Ochratoxin A occurred in cocoa samples screened during the study at very high concentrations and at lower concentrations in cocoa-based powder beverages. The high concentration of OTA in cocoa samples correlates with other studies on OTA in cocoa from other African countries and other countries worldwide (de Magalhães et al. 2011; Mounjouenpou et al. 2008). Dongo et al. (2008) reported OTA in 54 out of 56 Nigerian cocoa samples ready to be sold at concentration levels of 1.0-277.5ppb. In Cote d' Ivoire and Brazil, 23 out of 147 and 10 out of 151samples of cocoa from Abidjan and San Pedro respectively had over 2.0ppb of OTA contaminating them (Codex Alimentarius Commission 2008). Also in Spain, M. Sanchez-Hervas *et al*, (2008) isolated black *Aspergillus* species producing OTA from cocoa beans producing up to 90µg/g of OTA. Also, in Cameroun Mounjouenpou et al. (2008) isolated *A. niger* and *A. carbonarius* producing OTA in fermented cocoa seeds.

Lower levels of fumonisins were recorded in cocoa-based powder beverages in comparison to cocoa samples which could be attributed to the different production processes of cocoa-based powder beverage manufacture. Data showed a difference in incidence up to 16% of FB_1 contamination of cocoa seeds and cocoa-based powder beverages. One of the steps in cocoa-based powder manufacture is fermentation of cocoa seeds, followed by drying, cleaning, dehulling (husk removal), heat treatment, roasting and finally grinding (Cocoa story). These different steps and conventional methods of dehulling, drying and sorting have been reported to reduce mycotoxin contamination in food and are increasingly investigated as an approach in controlling mycotoxin problem in agriculture (Amezqueta et. al. 2009; Van Schothorst and Brooymans 1982). Also, the remarkable contamination of some cocoa-based powder beverage samples with high concentrations of ZEA above the set regulatory limit of 50- 1,000ppb could be attributed to improper production and post-production practices during the manufacture of cocoa-based powder beverages.

These mycotoxins occurring in the food commodities screened have been mentioned in association with a wide range of disease conditions inducing immune suppression, toxigenic effects, carcinogenic effects, mutagenic effects and carcinogenic effects in both humans and animals (Bünger et al. 2004; Richard 2007). The kidney and liver among other organs of the body are major targets of mycotoxins and have been reported in association with some kidney and liver

diseases and infections (Chu 1991; Meerdink 2002). In Nigeria, kidney and liver infections are quite common with liver cancer being one of the six most common cancers in the country (Abdulkareem 2009, Jedy-Agba et al. 2012) and aflatoxins were mentioned amongst other probable aetiological factors for the prevalence. In a survey by (Chijioke et al. 2010), there was a yearly progressive increased prevalence of different cystic kidney diseases in renal patients over a ten-year period. The occurrence of these mycotoxins at high concentrations is a cause for concern especially to the consumers of these food commodities as these mycotoxins sometimes withstand high temperatures and pressure and are likely to contribute to disease progression in individuals exposed to them.

V. CONCLUSION

Screening of samples showed a degree of contamination by almost all five major occurring mycotoxins in samples exceeding regulatory limits which should be a reason for concern because of the health implications. Also the fact that more than one mycotoxin was found occurring in the food commodities contribute to the increased concern because of the probable synergistic effects of the mycotoxins. A prolonged exposure to these mycotoxins over time could be detrimental to the health of individuals consuming these food commodities.

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