Ghana Journal of Horticulture (JHORT)
Vol. 14, No. 1, (2019), pp. 48-55
http://www.journal.ghih.org

Preliminary study on aflatoxin contamination of maize (*Zea mays*) grains in two districts of Northern Region of Ghana

Elias Nortaa Kunedeb Sowley[1]*, Frederick Kankam[1], Ahenkan Pious[1]

Department of Agronomy, Faculty of Agriculture, University for Development Studies, P.O. Box TL 1882, Tamale, Ghana

*Corresponding author: E-mail: esowley@uds.edu.gh

Abstract
Maize is among the most widely cultivated and consumed cereal crops in Ghana and across the world. The contamination of maize by aflatoxin in Ghana is a major concern due to the associated health hazards. This study investigated the levels of aflatoxin contamination in samples of maize grains collected from the Tamale Metropolis and the Tolon District of Northern Region of Ghana. Ten (10) maize samples were randomly collected from each district. Five (5) of these samples were collected from farmer's field and five (5) from market centers and sent to a laboratory for analysis. The levels of aflatoxin contamination were measured by liquid chromatography (HPLC-FLD) and post column derivatization. The results indicated significant difference between the districts with respect to the levels of aflatoxin contamination in the maize grains. The total mean aflatoxin recorded for the samples was 60.2 ± 0.66 ppb. The samples from Tamale and Tolon had 12.1 ± 0.32 ppb (20.1%) and 48.1 ± 0.34 ppb (79.9%) of aflatoxin, respectively. The maize grains collected from the markets had higher level of aflatoxin contamination (47.2 ± 0.30 ppb) compared with the grains from farmers' fields (13.1 ± 0.36 ppb). The study revealed that maize grains stored in polyethylene sack had the least level of aflatoxin while the jute sack had the greatest level of aflatoxin contamination. Therefore, it is recommended that maize grains should be stored in polyethylene sacks to reduce the level of aflatoxin contamination in the region.
Keywords: Aflatoxin; maize grains; farmers; sellers; jute sack; polyethylene sack

Introduction

Maize (*Zea mays*) is one of the most important crops cultivated and utilized as food for humans and feed for livestock in Ghana. Maize is a staple crop grown in almost all parts of the country, and is the most important source of carbohydrate in most Ghanaian meals. It has nearly replaced traditional staple crops like sorghum and pearl millet in northern Ghana (Coulter *et al*., 1993). Maize is the third most important crop after rice and wheat in the world and its economic importance and role in food security in Ghana cannot be over emphasized. Annual production has been more than 1,000,000 MT since 2000, averaging 1,772,300 MT over the period 2009 to 2012 (MoFA, 2013). In Ghana, maize is mainly produced by smallholder farmers under rain-fed conditions (SARI, 1996). It is estimated that about 692,034,148 MT of maize representing 31% of the world's cereals production was produced globally in 2005 (FAOSTAT, 2005).

ISSN: 0855-6350

Aflatoxins are a group of closely related heterocyclic compounds (mycotoxins) produced predominantly by two filamentous fungi, *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxin contaminates a wide range of food and agricultural commodities. Maize, just like any other crop can be contaminated with storage fungi, some of which may produce by-products such as mycotoxins that can be harmful to animals and humans. Contamination of crop produce by aflatoxins can occur in field of after harvest. Aflatoxins contamination of maize grains usually starts in the field or during storage (Kumar *et al*., 2000). Factors that predispose crop produce to aflatoxin contamination are high moisture content of produce, high relative humidity of storage environment, high temperatures, poor production practices such as early or late harvesting, poor storage structures and storage practices as well as biotic or abiotic stresses during the growth of the crops (Wilson and Payne, 1994; Hell *et al*., 2008). Aflatoxin contamination of human and animal feeds poses serious health and economic risks worldwide. The FAO estimates that 25% of the world food crops are being contaminated with mycotoxins each year and this contribute to significant post-harvest losses (FAO, 1997). It has been estimated that aflatoxin contamination of agricultural crops causes annual losses of more than US$ 750 million in Africa (Cardwell *et al*., 2004). Reports of high levels of aflatoxins in maize in Ghana and the health risk associated with it have been reported earlier (Kpodo, 1996). The main food products susceptible to fungal growth and consequently to mycotoxins' production, include peanuts, corn, wheat, rice, nut, walnuts, cotton seed, cassava, vegetable oils, cocoa and others that are normally used in the composition of foods and feeds (Setamou *et al*., 1997; Waliyar *et al*., 2015). Given that maize is the primary staple grain for Ghanaians, accounting for 36% of total food caloric intake (Kirimi *et al*., 2011); even relatively low levels of aflatoxins in the produce may result in significant health risk (Shephard, 2008).

In view of the health risk associated with mycotoxin contamination of foods, studies are being conducted worldwide to ascertain the occurrence of aflatoxins. For example, a survey of the occurrence of mycotoxins in feedstuffs and finished feeds in the Middle East and Africa has been widely reported (Rodrigues *et al*., 2009). The authors reported that 98% of the ingredients used in animal feed formulation were contaminated with aflatoxin B1. The contamination of meat and milk products by aflatoxins also contributes greatly to endangering the lives of people who consume these products (Kwiatkowski and Alves, 2007).

The aims of this study were to assess aflatoxin contamination of maize grains in two districts of the Northern Region of Ghana and evaluate the impact of maize storage methods on the level of aflatoxin contamination.

Materials and Methods

Source of maize grain samples

The samples of maize grains which were used in the study were collected from two districts of the Northern Region of Ghana. The maize variety, 'Obatanpa' which was used for the study is high yielding, has higher protein level and tolerant to pests and diseases such as stem borers, blight, rust and streak. The districts, Tolon and Tamale were randomly chosen from among other popular maize growing districts in the Northern Region of Ghana.

Maize sample collection

The maize samples were collected from farmers and maize sellers in Tamale and Tolon districts of the Northern Region of Ghana. The grain samples were collected randomly from the stores of five (5) farmer and five (5) market stores in each of the districts. In all twenty (20) samples were collected randomly from ten farmers and ten maize sellers. Whereas some of the samples from the farmers were still on their cobs partly due to the storage mode (hanging), all the samples from the maize sellers were grains, either packed in sealed sacks or in baskets and pans of different sizes. The samples collected were put in paper envelopes and taken to the Spanish Laboratory at the University for Development Studies, Nyankpala, for analysis.

Experimental design

The laboratory experiment was set up in completely randomised design with tree replications.

Detection of aflatoxin

The Vicam Aflatest kit was used for the aflatoxin analysis following the instructions of the Association of Official Analytical Chemists (AOAC). Maximum weight of 1 kg composite/aggregate sample was taken from each maize lot in each storage location after the 2016 cropping season and divided into three sub samples of about 300 g each, following the European Union (EU) standards (2003). Ground samples of about 25 g for each sub sample were used for the aflatoxin levels analyses and the average level calculated. The average moisture content of the sampled maize grains was 12.5%. The samples were ground for about fifteen (15) seconds using Agri-Grind grinder such that at least 75% could pass through a twenty (20) mesh sieve. A ratio of one parts of each sample and five parts of 65% ethanol were mixed. Thirty millilitres of the ethanol solution was added to the 10 g of each sample. The mixture was then vigorously shaken for one (1) minute. The contents were allowed to settle and then filtered through a filter paper. Twenty (20) red sample cups were arranged and 500 µL of sample diluent and 100 µL of the extracts were mixed in the cups. About 100 µL of the mixture was then transferred into a clear sample cup. A test strip was then placed in the cup with the sample end down. It was ensured that the strip came into contact with the liquid and began to wick. A timer was set for six (6) minutes. The strip was removed from the sample cup after it had developed for 6 minutes.

Aflatoxin analysis

The test strips were read at the end of 6 minutes incubation. The appropriate assay type (Aflatoxin in this case) was selected from the menu of the AccuScan reader. The Reveal Q+ test strip was fully inserted into the AccuScan reader with the sample end first. The AccuScan reader automatically analysed the test strip and the results were displayed and stored in the reader.

Data analysis

The data was analysed by the Analysis of Variance (ANOVA) with Genstat (9th edition) and treatment means were separated at 5% level of significance. Data sets on aflatoxin levels were subjected to and compared for significant difference based on the Probability (*P*) values.

RESULTS

Aflatoxin levels in samples from Tolon and Tamale Metropolis

There was a significant difference ($P < 0.05$) between the districts in their aflatoxin level. The mean concentration of aflatoxin in the maize samples of all the districts was 60.2 ± 0.66 ppb. Out of the total mean concentration recorded for the two districts, Tamale had a lower mean aflatoxin level of 12.1 ppb ± 0.32 ppb (20.1%) whiles Tolon had a higher value of 48.1 ± 0.34 ppb (79.9%) (Fig 1).

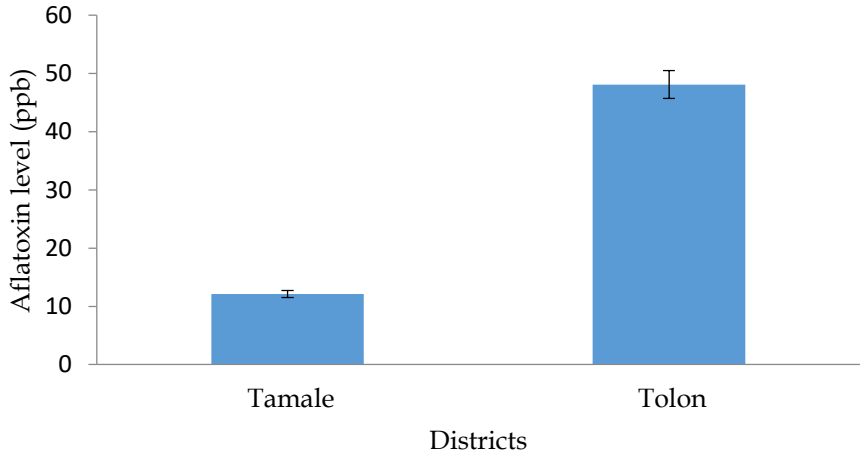

Figure 1: Aflatoxin levels in maize grains from Tolon District and Tamale Metropolis

Aflatoxin levels among the sample sources (markets and farmers)

Figure 2 showed significant difference ($P < 0.05$) in aflatoxin levels between the sample sources. The market samples generally had higher aflatoxin level than those from the farmers. The grains from markets had an average of 47.2 ± 0.30 ppb (78.2%) whiles grains from farmers had an average of 13.1 ± 0.36 (21.8%) ppb concentrations (Fig. 2).

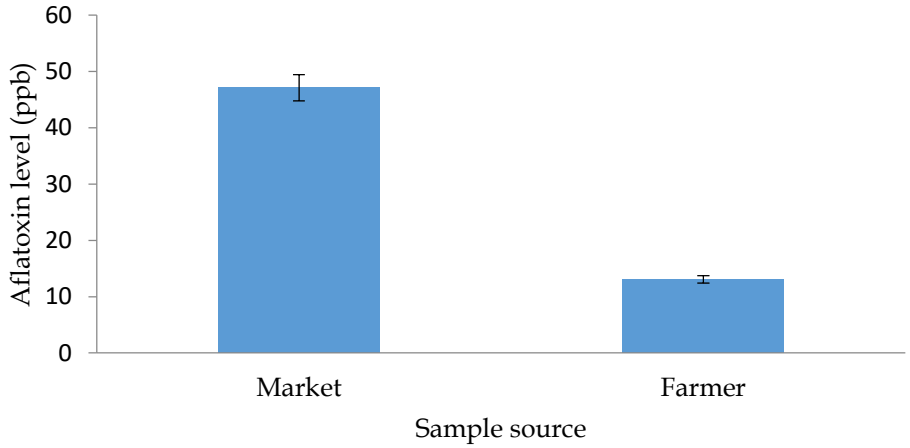

Figure 2: Aflatoxin levels in maize grains from farmers and market centres

Effect of storage containers on aflatoxin level

Storage is considered by many as a factor in the development of aflatoxin (Kaaya *et al*., 2006). The samples were either stored in polyethylene sacks or stored in jute sacks. There were significant differences ($P < 0.05$) among the individual storage practices in relation to the level of aflatoxin. Generally, grains stored in jute sacks had higher levels of aflatoxin, followed by grains which were stored in polyethylene sacks (Fig. 3).

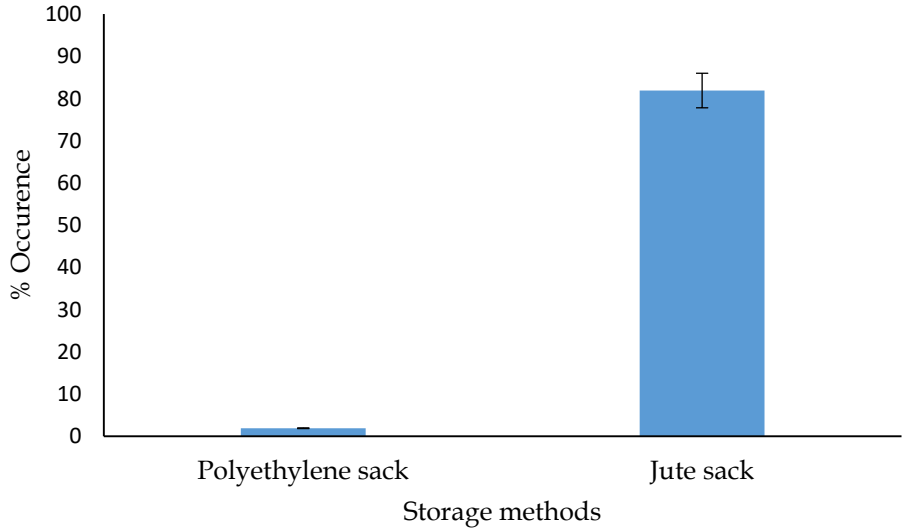

Figure 3: Effect of storage methods on incidence of aflatoxin

Discussion

Aflatoxin in maize has remained a significant challenge in most programs designed to improve production and utilization as well as linking small-holder farmers to the international market. This study investigated the prevalence of aflatoxin in maize in market centers and with farmers in the Tamale Metropolis and the Tolon District of Northern Region of Ghana. It also assessed the impact of two (jute sacks and polyethylene sacks) common storage containers on the level of aflatoxins in maize grains.

Generally, high levels of aflatoxin were recorded in maize grains obtained from the Tolon District compared to Tamale Metropolis. This could be attributed largely to the high temperature and humidity in the areas under survey. The standard limit for aflatoxin in maize consumed by humans is 20 ppb (FDA, 2011). This affirms the report of Diener *et al.* (1987) who indicated that optimal conditions for fungal development are 36 to 38ºC with high humidity of above 85%. It also supports the report of Hell *et al*. (2000) that significant correlations exist between Agroecozones (AEZ) and aflatoxin levels. It is also in line with Dohlman (2003) who reported that in as much as aflatoxins are ubiquitous; they are commonly found in warm and humid climates.

The presence of aflatoxin in all the maize samples collected indicates that maize is one of the crops largely colonized by aflatoxin contamination. This statement supports the assertion made by Groopman and Donahue (1988) that maize and its products are known to be prone to contamination by fungi that produce secondary metabolites such as aflatoxin. Maize is the primary staple grain for Ghanaians, accounting for 36% of total food caloric intake, even relatively low levels of exposure to aflatoxin may result in significant health threats (Kirimi *et al*. 2011; Shephard 2008).

Several studies conducted in developing countries reveal that some storage methods have influence on the level of aflatoxin contamination (Udoh *et al*., 2000). In this study, maize grains which were stored in polyethylene sacks had low level of aflatoxin contamination. It was likely that the temperature and relative humidity conditions within the polyethylene sack were not as conducive for the development of aflatoxin compared with the jute. In line with this claim, Hell *et al*. (2008) reported that aflatoxin contamination can increase 10 fold within a short period when harvested maize is stored under conditions of high moisture and temperature.

Conclusion

The results of the study have revealed that maize grains from Tolon District had higher level of aflatoxin compared to those from Tamale Metropolis. Also maize grains collected from market centres had higher levels of aflatoxin compared with those obtained directly from farmers. Maize grains stored in polyethylene sack had the least level of aflatoxin compared with jute sack having the greatest influence on aflatoxin level.

References

Cardwell, K. F. (2004). Yam chip food sub-sector: hazardous practices and presence of aflatoxins in Benin. 10th International Working Conference on Stored Product Protection. *Journal of Stored Products Research* 40: 575-585.

Coulter, J., Asante, E. O. and Ofei-Aboagye, E. (1993). Report on a seminar organized by the Ministry of Food and Agriculture, Accra, Ghana, 4 May 1993. p. 24.

Diener, U. L., Cole, R. J., Sanders, T. H., Payne, G. A., Lee, L. S. and Klich, M. A. (1987). Epidemiology of Aflatoxin, in formation by *Aspergillus flavus*. *Annual Review of Phytopathology* 25: 240-270.

Food and Drug Administration (FDA) (2011). Mycotoxin Regulatory Guidance; A Guide for Grain Elevators, Feed Manufacturers, Grain Processors and Exporters by National Grain and Feed Association. http://www.ngfa.org/wp-content/uploads/ NGFA Compliance Guide-FDA Regulatory Guidance for Mycotoxins 8-2011.

Groopman, J. D. and Donahue, K. F. (1988). Aflatoxin, a human carcinogen: determination in foods and biological samples by monoclonal antibody affinity chromatography. *Journal AOAC International* 71: 861-867

Hell, K., Cardwell, K. F., Setamou, M. and Poehling, H. M. (2000). The influence of storage practices on aflatoxin contamination in maize in four agro-ecological zones of Benin, *West Africa. Journal of Stored Products Research* 36: 365-382.

Hell, K., Fandohan, P., Bandyopadhyay, R., Cardwell, K., Kiewnick, S., Sikora, R. and Cotty, P. (2008). Pre-harvest and postharvest management of aflatoxin in maize. In: Leslie, J. F., Bandyopadhyay, R., Visconti, A. (Eds) *Mycotoxins: Detection Methods, Management, Public Health and Agricultural Trade*. CABI Publishing, Wallingford, UK. pp. 210-219.

Hoffmann, V., Mutiga, S., Harvey, J., Nelson, R. and Milgroom, M. (2013). Aflatoxin contamination of Maize in Kenya: Observability and Mitigation Behavior. Selected Paper prepared for presentation at the Agricultural and Applied Economics Association's 2013 AAEA and CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

Kaaya, A. N., Kyamuhangire, W. and Kyamanywa, S. (2006). Factors affecting aflatoxin contamination of harvested maize in the three agro-ecological zones of Uganda. *Journal of Applied Sciences* 6: 2401-2407.

Kirimi, L. N., Sitko, T. S., Jayne, F., Karin, M., Muyanga, M. S., Flock, J. and Bor, G. (2011). A Farm Gate to Consumer Value Chain Analysis of Kenya's Maize Marketing System, Egerton University Working Paper Series.

Kpodo, K. A. (1996). Mycotoxins in maize and fermented maize products in Southern Ghana. In: K. F. Cardwell, (eds). Proceedings of the workshop on "Mycotoxins in Food in Africa" (International Institute of Tropical Agriculture, Cotonou, Benin. November 6-10, 1995, p.33.

Kumar, P., Lava, S., Reddy, S. and Waliyar, F. (2000). Management of aflatoxins in maize; *Journal of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)*, Andrah, Pradesh, India.

Ministry of Food and Agriculture (MoFA) (2013). Agriculture in Ghana, Facts and Figures for 2012 issued by Statistical Research and Information Department (MoFA).

SARI (Savanna Agriculture Research Institute) (2016). SARI Annual Report, 2016

Setamou, M., Cardwell, K. F., Schulthess, F. and Hell, K. (1997). *Aspergillus flavus* infection and aflatoxin contamination of preharvest maize in Benin. *Plant Disease* 81: 1323-1327.

Shephard, G. S. (2003). Aflatoxin and food safety: recent African perspectives. *Toxin Reviews* 22: 267-286.

Shephard, G. S. (2006). Mycotoxins in the context of food risks and nutrition issues. *In*: Barug, D. D., Bhatnagar, H. P., Egmond, V., Kamp, V. D., W. A., Osenbruggen, V. and Visconti, A. (Eds.). *The Mycotoxin Factbook: Food and Feed Topics*, pp: 21–36. Wageningen Academic Publishers, Wageningen, The Netherlands.

Udoh, J. M., Cardwell, K. F. and Ikotun, T. (2000). Storage structures and aflatoxin content of maize in five agroecological zones of Nigeria. *Journal of Stored Products Research* 36: 187-201.

Waliyar, F., Osiru, M., Ntare, B. R., Vijay, K. K. K., Sudini, H., Traore, A. and Diarra, B. (2015). Post-harvest management of aflatoxin contamination in groundnut. Special issue: Aflatoxins in maize and other crops. *World Mycotoxin journal* 8(2): 245-252.

Wilson, D. M. and Payne, G. A. (1994). Factors affecting *Aspergillus flavus* Group Infection and Aflatoxin Contamination of Crops, The Toxicology of Aflatoxins: Human Health, Veterinary, and Agricultural Significance, (Eaton DL, Groopman JD, eds., San Diego, CA)