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Research Article

# Adoption of Post-Harvest Strategies to Minimize Aflatoxin Contamination in Groundnut (*Arachis Hypogaea*) in Ghana

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## Abstract

Aflatoxin, a mycotoxin caused by the mold *Aspergillus flavus* or *parasiticus,* can have negative impacts on human health, especially vulnerable populations. Several management practices can minimize risk of contamination of groundnut (*Arachis hypogaea L.*). A survey was conducted with thirty-six farmers who were involved in research designed to develop strategies to minimize aflatoxin contamination in groundnut in northern Ghana in 2017 and again in 2020. Fewer farmers in 2020 were consuming groundnuts with mold that produces aflatoxin or selling grain suspected of containing aflatoxin in local markets. Farmers increased use of tarpaulins as a drying surface in 2020 compared with 2017. Drying on tarpaulin has been shown to reduce aflatoxin contamination going into storage by minimizing spores on groundnut and enabling farmers to cover their crop when rain occurs after harvest and initial drying of pods. Hermetically-sealed bags limit fluctuations in humidity and can maintain groundnut moisture at optimum levels during storage. Farmers did not adopt hermetically-sealed bags to minimize aflatoxin, most likely because of availability and cost. Results from this longitudinal study provide knowledge on what aspects of aflatoxin mitigation after harvest need to be addressed in future research.

## Introduction

Groundnut *(Arachis hypogaea L.)* is an economically important crop in Ghana and other regions of the world and contributes to food security [1,2]. A wide range of pests can adversely affect groundnut yield and quality if populations are not maintained at low levels during the cropping cycle [3]. In addition to pre-harvest losses, poor drying and storage conditions can reduce marketable yield and quality for direct consumption by smallholder farmers and marketing opportunities [4,5]. In addition to issues associated with food security through lower yields, approaches to drying groundnut prior to storage and conditions of storage can affect safety of groundnut for consumers [4,5]. Aflatoxin (caused by *Aspergillus flavus* and *parasiticus)* can adversely affect human health [6,7,8]. Developing approaches to dry and store groundnut that minimize aflatoxin contamination could decrease risk to consumers and increase marketing options for smallholder farmers.

Research was conducted in Ghana to determine the impact of pre-harvest and post-harvest strategies on groundnut yield and aflatoxin contamination [4,9]. In these experiments, drying groundnut on tarpaulins and storing the crop in hermetically-sealed bags decreased aflatoxin contamination after 4 months of storage and increased marketable groundnut (e.g., groundnut kernels without mold and damage). Results from these experiments provide options for smallholder farmers to suppress pests present during the cropping cycle and methods to mitigate aflatoxin contamination during the drying and storage steps in the process [4,9]. However, these options (e.g., drying on tarpaulins or storing in hermetically-sealed bags) have limitations relative to access and expense for resource-poor farmers.

Determining adoption rates of improved practices is important in understanding why interventions are adopted or not in the farming community. To address this issue with respect to aflatoxin mitigation, a survey of farmers involved in the work outlined by Abudulai et al. [9] was conducted in 2017 and again later in 2020. The longitudinal study documented impact of the research program and Farmer Field Schools associated with the initial research.

## Materials and Methods

Research was conducted in 2016 and 2017 by the Savannah Agricultural Research Institute of the Council for Scientific and Industrial Research with financial support from the USAID Feed the Future Peanut and Mycotoxin Innovation Lab in three communities in northern Ghana (Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district) [9]. The initial survey was conducted in November and December 2017 with the follow up survey completed in November 2020. The communities and participating farmers were selected because of involvement in the research project outlined by Abudulai et al. [9]. Consent from each person surveyed was received, and the survey was pre-coded to ensure non-disclosure of identity. In each community, twelve farmers who collaborated on the research trials [9] were interviewed on a wide range of topics associated with peanut farming. The total number of farmers involved in the research project [9] and survey in 2017 and 2020 was 36. In this paper, we discuss knowledge of aflatoxin in groundnut and adoption of post-harvest interventions (e.g., drying and storing) included in the trials. Data from 2017 and 2020 were analyzed using Stata 14 software. Means were compared using Chi-squared tests and the student t-test for mean differences at $p < 0.05$.

## Results and Discussion

At least 95% of farmers in 2017 and 2020 indicated that they had heard of aflatoxin (Table 1). No attempt was made to determine the extent of their knowledge about the implications of consuming aflatoxin-contaminated grain. In 2020, fewer farmers observed aflatoxin in their grain compared with 2017 while more farmers removed aflatoxin-contaminated grain before eating and selling in 2020. Farmers reported that aggregators increased monitoring of grain prior to purchase in 2020 compared with 2017. Collectively, these data indicate that farmers improved their approach to consumption and marketing groundnuts thus contributing to increased food safety. This survey was not designed to determine whether the catalyst for increased food safety was associated with a greater perception of the need to minimize the negative health impacts of aflatoxin or if these changes were associated with a greater demand for safer groundnut from aggregators.

**Table 1:** Percentage of thirty-six farmers in 2017 and 2020 stating a positive response (yes) to issues or actions associated with aflatoxin contamination in groundnut.

| Issues or Action | 2017 | 2020 | Chi-Square Test* |
|---|---|---|---|
| Heard about aflatoxin before? | 100 | 95 | NS |
| Observation of aflatoxin-contaminated grain in farmers' groundnuts | 92 | 86 | S |
| Removal of aflatoxin-contaminated grain before eating? | 94 | 100 | S |
| Removal of aflatoxin-contaminated grain before selling? | 86 | 73 | S |
| Aggregator cross-checking for aflatoxin contamination? | 69 | 90 | S |

*S = Significant; NS = Not Significant; 95% Confidence Interval.

In 2017, 56% of famers indicated that they discarded aflatoxin-infested grain (Table 2). In contrast, this number increased to 71% in 2020. Of concern is the reported rise in the use of aflatoxin-contaminated groundnut for soup or stew in 2020 compared with 2017. In 2017 a higher percentage of farmers disposed on groundnut with aflatoxin by burning or burying in soil compared with results in 2020. Less than 5% of farmers used groundnuts contaminated by aflatoxin as animal feed or sold in the market in both years.

**Table 2:** Percentage of thirty-six farmers in 2017 and 2020 associated with disposal of aflatoxin-contaminated groundnut grain.

| Action | 2017 | 2020 | Chi-Square Test* |
|---|---|---|---|
| Throw away | 56 | 71 | S |
| Use for soup/stew | 0 | 21 | S |
| Burn | 14 | 0 | S |
| Animal feed | 3 | 5 | NS |
| Sell in market | 0 | 0 | NS |
| Bury in soil | 25 | 3 | S |
| No action | 2 | 0 | NS |
| Number of observations | 36 | 36 | |

*S = Significant; NS = Not Significant; 95% Confidence Interval.

Farmers increased drying of groundnuts on tarpaulin or poly sheets in 2020 compared with 2017 (Table 3). There were also fewer farmers drying groundnut on bare ground or cemented floors in 2020 compared with 2017. Drying on platforms or using other methods comprised less than 5% of farmers in 2017 and 2020. Abudulai et al. [9] and Appaw et al. [4] reported that drying groundnut on tarpaulins rather than on the bare ground decreased aflatoxin contamination.

**Table 3:** Surfaces used by thirty-six farmers to dry groundnuts in 2017 and 2020.

| Drying surface | 2017 | 2020 | Chi-square test* |
|---|---|---|---|
| Bare ground or cemented floor | 64 | 46 | S |
| Tarpaulin or poly sheet | 33 | 46 | S |
| Platforms | 3 | 5 | NS |
| Other | 0 | 3 | NS |
| Number of observations | 36 | 36 | - |

*S = Significant; NS = Not Significant; 95% Confidence Interval.

The primary container that farmers used to store groundnut after drying was either a polysac or fertilizer bag (Table 4). While the number of farmers using fertilizer bags for storage increased in 2020 compared with 2017, there was no difference in the number of farmers storing groundnut in polysacs. Fertilizer bags are considered more durable than polysacs, and use of fertilizer bags would be more effective in protecting groundnut from storage pests compared with polysacs. Additionally, farmers often have fertilizer bags readily available from fertilizer purchase earlier in the cropping cycle for other crops. A similar percentage of farmers stored groundnut in jute sacs; storage in hermetically-sealed bags was less than 3% during both years. Abudulai et al. [9] reported that drying groundnut on tarpaulin and storing in hermetically-sealed bags was more effective in reducing aflatoxin than drying groundnuts on bare ground and storing in polysacs. Similarly, Appaw et al. [4] reported that drying on tarpaulin or storing in hermetically-sealed bags made positive contributions to decreasing aflatoxin contamination after storage. The combination of drying on tarpaulin and storing in hermetically-sealed bags was more effective than using only one improved practice for aflatoxin mitigation. Appaw et al. [4] also demonstrated that grain quantity and quality were greater when these interventions were employed individually or in concert. Based on the assumptions of their economic analysis, greater financial return from improved drying and storing approaches covered the cost of each intervention employed separately or together [4].

**Table 4:** Change in methods employed by thirty-six farmers in 2017 and 2020 to store groundnuts.

| Storage container | 2017 | 2020 | Chi-square test* |
|---|---|---|---|
| Polysacs | 42 | 38 | NS |
| "Fertilizer" bags | 33 | 54 | S |
| Hermetically-sealed bags | 0 | 3 | NS |
| Jute sacs | 6 | 5 | NS |
| Open pans | 0 | 0 | NS |
| Number of observations | 36 | 36 | |

*S = Significant, NS, Not Significant, 95% Confidence Interval.

Several reasons could explain the adoption of the tarpaulins for drying but not the hermetically-sealed bags. Tarpaulins are available in local markets and would constitute a relatively small fraction of the budget for groundnut production [4]. Conversely, hermetically-sealed bags are less available in some areas of Ghana and the associated cost is greater than for tarpaulins depending on groundnut yield and storage requirements. Limitations of financing tarpaulins and hermetically-sealed bags are likely barriers to adoption of these approaches, especially hermetically-sealed bags.

Our results indicate that farmers allowed fewer groundnuts to enter the market but may have concentrated aflatoxin in soups and stews in 2020 compared with 2017. Farmers dried groundnut in a manner that most likely would limit increases in aflatoxin contamination (e.g., drying on tarpaulin rather than bare soil or cement flooring) but did not use hermetically-sealed bags. Collectively, these findings indicate that education on the negative impacts of aflatoxin on food safety and increased scrutiny by aggregators could decrease aflatoxin in groundnut. Limited adoption of proven interventions during drying and storing (e.g., dry on tarpaulins and storing in sealed bags) suggests that greater education on the benefits of these practices is needed while increasing financial credit for purchasing these items would likely promote adoption.

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