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RESEARCH ARTICLE

The role of manual sorting of raw peanuts to minimize exposure to aflatoxin-contaminated peanuts

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ABSTRACT

The occurrence of toxic concentrations of aflatoxin in peanuts requires appropriate intervention. In countries such as Zambia with poor implementation of existing regulatory standards, consumer action can minimize risk of exposure. The current study evaluated the significance manual removal of shriveled, externally-discolored, misshapen, mechanically-damaged and insect-damaged kernels to minimize the baseline aflatoxin content in peanut samples. One hundred and two (102) aflatoxin-contaminated samples of raw peanuts each weighing 1 kg were collected. Each sample was sub-divided into two 500 g- subsamples of which one was manually sorted to remove contaminated kernels before the paired samples were each tested for total aflatoxin content. Results of a paired sample t-test showed an average of 56% reduction in mean total aflatoxin content from an initial 10.4 µg/kg (range of 5.2 to 18 µg/kg). Although manual sorting can be tedious for large lots and may not remove contaminated but visually sound kernels, careful sorting of raw kernels prior to consumption or processing into other peanut products is an essential step to minimize aflatoxin content. Responsible peanut consumers should embrace this practice to minimize aflatoxin content in their food.

Keywords: Aflatoxin, manual sorting, peanut kernels, Zambia

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is the second most cultivated crop in Zambia after maize (Mukuka and Shipekesa, 2013). It is an important source of protein, edible oil, vitamins and minerals (Savage and Keenan, 1994). Nevertheless, the high incidence of aflatoxins in peanut kernels and related products compromise the safety of peanut based food stuff. Aflatoxins are carcinogenic toxic chemical metabolites of toxigenic moulds, predominantly *Aspergillus flavus* and *A. parasiticus* (Richard and Payne, 2003). The consumption of aflatoxin-contaminated food has been linked to many health challenges and can cause death in acute cases (Williams et al., 2004; Murphy et al., 2006). In Zambia, a study showed a link between stunting among children under the age of five years to consumption of aflatoxin contaminated food (Ismail et al., 2014).

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Results of a recent three-year survey on aflatoxin B1 (AFB_1) concentration in peanut kernels and milled powder from the major peanut producing districts and selected urban areas of Zambia revealed that whole kernels had mean AFB_1 concentrations higher than 20 µg/kg in all the study locations. A comparison in AFB_1 concentration between whole kernels and milled peanut powder showed that AFB_1 concentrations in milled peanut powder were not always lower than in whole kernels suggesting a lack of systematic removal of contaminated kernels before milling (Njoroge et al., 2017).

Manual removal of highly contaminated peanut kernels such as discoloured, shrivelled, misshapen, undersized, insect damaged or mechanically broken kernels can significant reduce the baseline aflatoxin content in a sample. A study in Gambia, West Africa, showed that the removal mouldy kernels from contaminated samples resulted in 42.9 % reduction in AFB_1 levels from a baseline concentration of 11.4 µg/kg (Xu et al., 2016). With only 2 % loss of the initial mass of the sample after the sorting exercise suggests that only a small proportion of kernels per sample were highly contaminated with aflatoxin. In the Philippines, Galvez et al. (2003) also observed significant reduction in aflatoxin content following manual sorting of blanched peanuts from an initial total aflatoxin concentration of 300 ppb to less than 15 ppb.

Considering the reportedly high aflatoxin contamination levels even amidst existing regulations on aflatoxin, consumers need to make personal effort to minimise the risk of exposure. The current study emphasised manual identification and removal of contaminated kernels by consumers themselves as a responsible means of groundnut consumption. The study had two main objectives: to evaluate the efficacy of manual sorting to reduce total aflatoxin content in peanut kernels and to evaluate the effect of the baseline aflatoxin content on aflatoxin content in sorted samples. The results are discussed in terms of the significance of manual sorting as an intervention towards responsible peanut consumption in areas with high risk of exposure to aflatoxin-contaminated peanuts.

MATERIALS AND METHODS

Sampling

One hundred and two (102) samples of unsorted sun-dried raw peanut kernels were collected from on-station field experiments meant to evaluate the effects of selected agronomic practices on the risk of aflatoxin contamination of kernels before harvesting. These experiments were situated in Chipata (24 samples), Chongwe (62 samples) and Lusaka (16 samples) Districts of Zambia (Figure 1). Each sample weighed 1 kg and was sub-divided into two 500 g sub-samples, which were processed for aflatoxin analysis separately.

Sorting and aflatoxin analysis

The samples for sorting were first cleaned to remove all the debris and then sorted by hand to remove kernels suspected to be highly contaminated with aflatoxin before further processing for aflatoxin testing. The sorting process involved visually identifying and then manually removing all the contaminated kernels, which included shriveled, mechanically broken, discolored, misshapen and insect-damaged kernels. For uniformity, all the samples were sorted by one trained individual. After sorting, the samples were clearly labeled and temporarily stored in sanitized air-tight plastic jars at room temperature and were tested for aflatoxin content within a week after sorting. The remaining unsorted 500 g sub-sample was milled and analysed for aflatoxin content without any sorting intervention. For both the sorted and unsorted sub-samples, entire 500 g samples were milled using a kitchen grinder (LM2211BM, Moulinex, China) and thoroughly mixed by shaking. The milled samples constituted laboratory samples. Three sub-samples were analyzed from each of the 500-g- samples tested. Total aflatoxin content in each sub sample was determined using the Reveal® Q+ aflatoxin test kit (Neogen Corporation, USA).

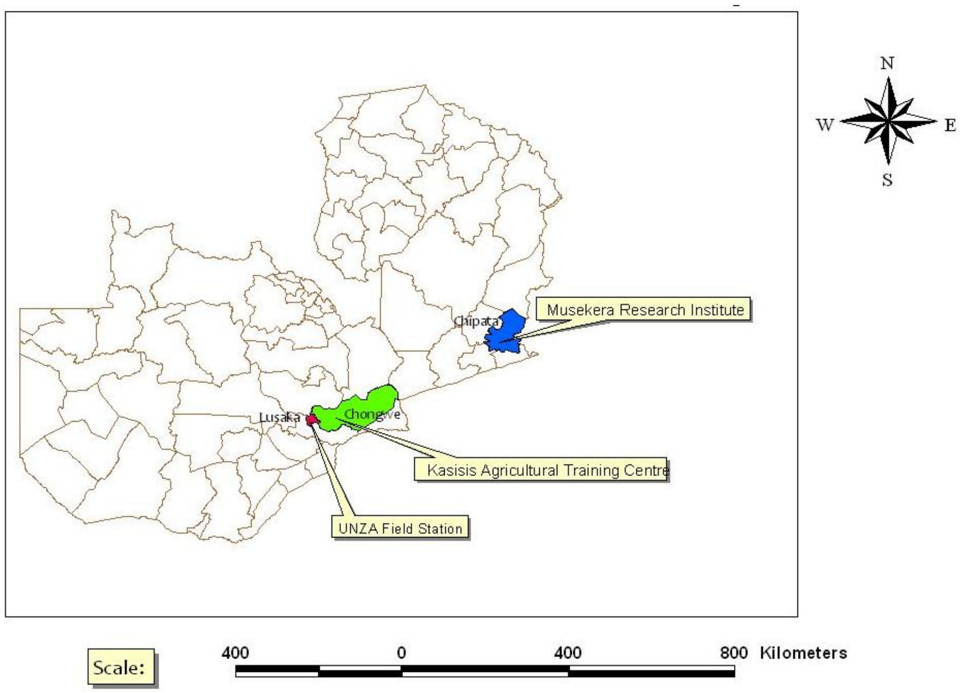

Figure 1: Map of Zambia showing the three locations for sample collections

Baseline aflatoxin content

Based on total aflatoxin content in the unsorted samples, the samples were divided into two groups: Lot 1 (n = 42), being samples with total aflatoxin content less than 10 µg/kg and Lot 2 (n= 60), being samples with total aflatoxin content of 10 µg/kg and above. In Lot 1, samples had total aflatoxin content ranging from 5.2 to 9.9 µg/kg. Lot 2 constituted samples with total aflatoxin content ranging from 10 to 18 µg/kg. According to the Zambia Bureau of Standards Standard Number ZS 723, the maximum permissible limit on total aflatoxin content in peanut is 15 µg/kg. In this study, only 4 samples had aflatoxin content exceeding this limit. Thus, a lower critical limit of 10 µg/kg was adopted as the most widely applied critical limit among African countries (FAO, 2004). The essence of this grouping of samples was to evaluate the impact of the initial total aflatoxin content on the total aflatoxin content of the sorted sample.

Data analysis

Statistical analysis of the data was done in R-statistical software (2017, The R Foundation). Data points with studentized residuals with an absolute value of 3 were judged to be outliers. Going by the large sample size (n = 40 for Lot 1 and n = 62 for Lot 2), the central limit theorem was applied to assume normal distribution of the data. The Levene's test of homogeneity of variances was performed and test results showed that the data fulfilled this assumption. Paired sample t-tests were then performed to determine statistical significance in total aflatoxin levels between the unsorted and sorted samples in each of the two lots. Statistical significance was judged at 5%.

RESULTS AND DISCUSSION

There was a significant difference in total aflatoxin content between sorted and unsorted sub-samples (Table 1). The mean total aflatoxin content was significantly lower in sorted kernels than in the unsorted sub-samples. Total aflatoxin concentration in sorted kernels was on average 56% lower than in unsorted kernels across the two lots. Results also showed that the total aflatoxin content in the sorted samples was a function of the initial total aflatoxin content (Figure 2). Lot 2 which had a higher initial total aflatoxin content had significantly higher total aflatoxin content in the sorted kernels than sorted samples in Lot 1 with lower initial total aflatoxin content. This result suggests a limitation on the applicability of sorting to minimize aflatoxin levels in highly contaminated kernels.

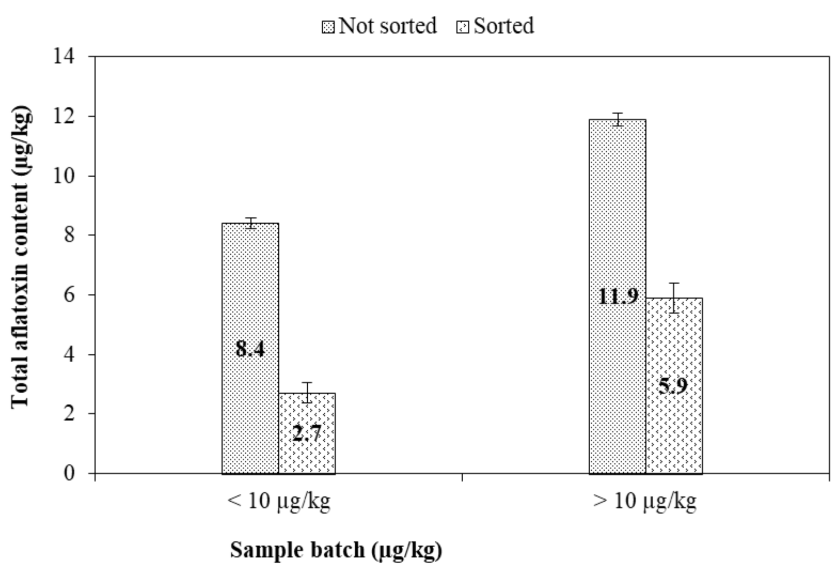

Figure 2: Plot of total aflatoxin content in peanut kernels before and after sorting intervention

Table 1: Output table showing results of the Paired t-test on mean difference in total aflatoxin content between the sorted and unsorted groundnut samples

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        Paired t-test

data:  Sorting$Not.sorted and Sorting$Sorted

t = 19.221, df = 101, p-value < 2.2e-16

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

 5.270279 6.483316

sample estimates:

     mean of the differences | std.dev. of the differences

                5.876797                         3.087887
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Significance of sorting to minimize total aflatoxin concentrations

This study has shown that manual removal of contaminated kernels is an intervention that can minimize total aflatoxin content in a peanut sample. These results are in agreement with results from other studies (Dickens and Whitaker, 1975; Galvez et al., 2003; Xu et al., 2016). Sorting is especially important in regions such as sub-Saharan Africa where the risk of aflatoxin exposure due to high incidences of aflatoxin contamination of peanuts coupled with challenges in enforcing the existing regulations on permissible limits (Matumba et al., 2015; Njoroge et al., 2017; Magamba et al., 2017).

In Zambia, peanut-based food products are an important component of weaning food for infants as earlier observed by Hayes et al. (1994). With peanut being the second most grown food crop among small holder farmers in Zambia (Mukuka and Shipekesa, 2013), the current trend in consumption is likely to continue for the many decades to come. Hand-sorting remains a low-cost practical measure that can be used to minimise total aflatoxin concentrations in relatively small-sized whole peanuts samples.

Since the discovery of aflatoxin in 1960 (Richard, 2008), sorting to remove contaminated kernels has been an essential step in minimising total aflatoxin levels in commercial peanut lots (Dickens and Whitaker, 1975). According to Whitaker et al. (1998) damaged kernels accounted for 93 % of the total aflatoxin content in a lot. In Gambia, a study on manual sorting of peanut samples resulted in the loss of only 2 % of the initial mass of sample and yet resulted in 42.9 % reduction in AFB_1 content in sorted samples (Xu et al., 2016). In the current study, debris and bad kernels together accounted for less than 10 % of the total mass in all the samples and yet resulted in more than 50 % reduction in total aflatoxin content in both sample lots. This result showed that better quality peanut food is attainable with minimal effort by consumers themselves who would benefit from safer food.

Considering the low levels of total aflatoxin in the sorted samples in Lot 1, hand-sorting of raw peanut samples was sufficient to produce samples that meets one of the most stringent regulations such as the EU maximum limit of 4 µg/kg for peanuts meant for direct consumption (EC 2010), while sorted samples in Lot 2 with total aflatoxin concentration of 5.9 ± 0.49 µg/kg would still be accepted under EU legislation for peanut kernels meant for further processing. Access to the highly restricted international markets, which Zambia lost in the 1970s (Ross and Klerk, 2012; Mukuka and Shipekesa, 2013) would earn the country foreign exchange income.

Pitfalls of hand sorting

Given that the distribution of aflatoxin in a seed lot can be so uneven that only a small proportion of the sample maybe contaminated (Whitaker, 2003), the success of any sorting technique largely depends on the ability to identity contaminated kernels. Effective sorting should therefore target the removal of such kernels from a given lot. In peanuts, aflatoxin contamination is often high in shrivelled, mechanically broken, discoloured, misshapen and insect-damaged kernels when compared with normal fully-matured intact kernels (Mutegi, 2009). The current study had cases where sorting had no significant effect on total aflatoxin content in sorted samples suggesting that aflatoxin incidence can also be high even in visually sound kernels. The implication is that the only sure way to know if the produce meets the regulatory standard would be to test for aflatoxin content before consumption.

In comparison with electronic color sorting, manual sorting can be considered labor intensive for bulk samples. However, the cost associated with electronic sorters is prohibitive to most small scale traders in developing countries. This calls for action by consumers themselves who can benefit from manual sorting of samples meant for home consumption. Nonetheless, in most developing countries, the willingness to sort grain meant for home consumption mostly depend on the availability of food supplies (Fandohan et al., 2008). Households with meagre supplies may be tempted mix good and poor quality kernels and consume them as milled products or feed the poor quality kernels to livestock such as poultry. Adu-Gyamfi, (2013), reported that the quality of nuts consumed improved with an increase in household income and education in a Ghanaian community. This finding suggests that food security is a key determinant of the willingness to ensure food safety. In other words, most individuals tend to be insensitive to food safety in the absence of food security.

CONCLUSION

This study demonstrates that careful sorting of raw peanut kernels prior to consumption or processing into other peanut products is an essential step to minimize total aflatoxin levels in the consumed product. Considering the complexity of food safety in most developing countries, responsible consumption of peanuts and related food products is a more viable food safety measure. Therefore, promotions on the use of peanut based foods as weaning food for children should go hand in hand with awareness campaigns on the food safety concerns about peanuts. Programs to encourage manual sorting should approach this subject holistically which would imply emphasizing benefits alongside the major challenges such as lack of incentives, technical aspects and labor demands.

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