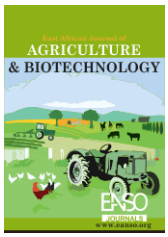

East African Journal of Agriculture and Biotechnology
eajab.eanso.org
Volume 7, Issue 1, 2024
p-ISSN: 2707-4293 | e-ISSN: 2707-4307
Title DOI: https://doi.org/10.37284/2707-4307

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya

Clara C. Kirui[1], *Eunice A. Mewa*[2*] *& Jaspher K. Imungi*[1]

[1] University of Nairobi, P. O. Box 29053-00625, Nairobi, Kenya.
[2] University of Eldoret, P. O. Box 1125-00300, Eldoret, Kenya.
* Author for Correspondence ORCID: https://orcid.org/0000-0002-4558-9440; Email: eunicemewa@yahoo.com

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Date Published: *12 August 2024*

Keywords: *Aflatoxin, Maize, Decontamination, Traditional, Processing methods.*

ABSTRACT

Aflatoxins are fungal secondary toxic metabolites produced predominantly by certain strains of the Aspergillus molds. The objective of this study was to investigate the effectiveness of Kenyan traditional processing methods in reduction of aflatoxin in maize. The traditional methods used included; alkaline cooking using Magadi soda and maize cob ash, decortication by pounding wet maize with mortar and pestle, dehulling in mechanical mill and exposure to solar radiation. Standardization of alkali cooking was done before actual treatment of the contaminated samples. Naturally contaminated samples of maize were sampled and used in the experiment. Aflatoxin analysis before and after each of the treatments was done using ELISA method and total aflatoxins were expressed in parts per billion (ppb) (dry weight basis). The results were subjected to statistical analysis at 5% significance levels ($p \leq 0.05$). The reduction of aflatoxin was found to be highest when maize was boiled in maize cob ash solution which resulted in loss of aflatoxin from 83.1±0.3 ppb to 7.0±3.9 ppb. Dry decortication reduced aflatoxin from 51.3±15.3 to 9.6±0.8 ppb, boiling in Magadi soda led to a drop from 59.5±3.818 ppb to 13.4±0.424 ppb, solar irradiation caused a drop from 60.8±1.8 ppb to 13.7±0.1 ppb and pounding in Magadi soda resulted in least loss of aflatoxin from 81.5±0.3 to 72.7±0.2ppb. Aflatoxin loss in all the treatments was significant except for dry decortication. Only dry decortication and boiling in maize cob ash solution brought down the aflatoxin levels to below the maximum allowable limit as set by the Kenya Bureau of Standards (10ppb).

APA CITATION

Kirui, C. C., Mewa, E. A. & Imungi, J. K. (2024). Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya. *East African Journal of Agriculture and Biotechnology*, *7*(1), 389-398. https://doi.org/10.37284/eajab.7.1.2097

CHICAGO CITATION

Kirui, Clara C., Eunice A. Mewa and Jaspher K. Imungi. 2024. "Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya". *East African Journal of Agriculture and Biotechnology* 7 (1), 389-398. https://doi.org/10.37284/eajab.7.1.2097

HARVARD CITATION

Kirui, C. C., Mewa, E. A. & Imungi, J. K. (2024) "Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya.", *East African Journal of Agriculture and Biotechnology*, 7(1), pp. 389-398. doi: 10.37284/eajab.7.1.2097.

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

IEEE CITATION

C. C. Kirui, E. A. Mewa & J. K. Imungi "Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya", *EAJAB*, vol. 7, no. 1, pp. 389-398, Aug. 2024.

MLA CITATION

Kirui, Clara C., Eunice A. Mewa & Jaspher K. Imungi. "Assessment of the Traditional Processing Methods in the Reduction of Aflatoxin Levels in Maize and Maize Products in Kenya". *East African Journal of Agriculture and Biotechnology*, Vol. 7, no. 1, Aug. 2024, pp. 389-398, doi:10.37284/eajab.7.1.2097

INTRODUCTION

Aflatoxins are potent toxic, carcinogenic, mutagenic, immunosuppressive agents, produced as secondary metabolites mainly by the fungus *Aspergillus flavus* and *Aspergillus parasiticus* (Reddy *et al.*, 2011). The fungus invades several crop species and under certain environmental conditions produces aflatoxins before and after harvest under conditions that occur quite commonly in crop species like maize and groundnuts (Pitt *et al.*, 2013). In maize particularly, it can occur in the standing crops during the late milk stage when there is high precipitation in the environment or when there is drought stress (Williams *et al.*, 2004). It can also accumulate post-harvest when maize is stored with improper drying and storage in non-ventilated storage or in adverse storage conditions which allow moisture reintroduction either through leakages or damp storage conditions, through insect infestation and high temperatures (Hell *et al.*, 2011). *Aspergillus parasiticus* produces four major aflatoxins: B1, B2, G1 and G2, in which the toxicity is in the order of B1 > G1 > B2 > G2 (Domer, 2004).

Maize is the main dietary staple of Kenyans, and it is also one of the crops most susceptible to infection by *Aspergillus flavus* contamination. Kenya is one of the world's hotspots for aflatoxin as shown by the survey done by the International Food Policy Research Institute. From 2004 to 2006, about 200 Kenyans died after consuming aflatoxin contaminated maize (IFPRI, 2011). A report by FAO/WHO names aflatoxins among the four chemicals which have a substantial impact on the food-borne burden of disease, (WHO, 2015). The combination of good agricultural practices and the use of proper controlled storage conditions are used to minimize the potential for mycotoxin contamination, however these strategies have been shown to be unable to assure elimination of mycotoxin producing organisms. Decontamination techniques are further needed to control aflatoxin risk.

Recent research activities seem to be shifted towards reducing aflatoxin already present in foods. Several biological, physical, and chemical methods have been tested and evaluated in the mitigation of aflatoxins (Sipos *et al.*, 2021). However, most farmers in Kenya are not well equipped with detoxifying methods. Infact, novel methods of detoxification have rarely been used as they are expensive and not easily available. The main aim of the decontamination is to inactivate, destroy or remove the toxin without any change in the nutritive value and food/feed acceptability of the product (Marshall *et al.*, 2020). Due to above reason, dry dehulling, Magadi soda (natural soda ash) decortication, ash decortication and solar radiation could be the most cost effective, easy to use and easily available local methods of reducing aflatoxin contamination if their effectiveness is proven. UV radiation could be exploited for use commercially by incorporating it to the commercial drying system. This study therefore, aimed at assessing the effectiveness of of these traditional and improved processing methods in the reduction of aflatoxin levels in maize and maize products.

MATERIALS AND METHODS

Collection of Samples

Bagged maize which had been mopped up from farmers after it was confirmed as aflatoxin positive was randomly sampled from the NCPB stores by spiking randomly using sack-type spear to 90 kg bulk sample (KEBS 2008-KS EAS 79:1999). This sample was then mixed thoroughly to homogenize it using sample divider cum homogenizer which mixes the sample. The initial

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

moisture content of the samples was analyzed at a fixed temperature of 105 °C using method 967.08 (AOAC, 2005). The bulk sample was then divided into six parts each of 15 kgs for the six treatments i.e. wet decortications, dry decortications, boiling in Magadi soda, boiling in maize cob ash, solar irradiation and UV irradiation. The samples to be used in the experiments was hand-sorted to remove rotten diseased (and discolored maize then passed through a 4mm sieve to remove any foreign matter. The samples were then kept in the dark during the experiment period. Aflatoxin testing for the samples was done using Enzyme Linked Immunosorbent Assays (ELISA) as outlined in the training manual courtesy of Boratest® Technology (Bora Biotech® Ltd., 2009).

Alkaline Decortication of Contaminated Maize Samples

Pretrial process

The process was standardized by a pretrial process, where progressive weights of Magadi soda of 25g, 50g, 75g and 100g were admixed with 250g of maize and 750ml of water and boiled till the testa dissolved readily the effectiveness of decortication was observed by taking a cooked grain and rubbing against the thumb and the index finger to feel the ease with which the pericarp comes off. The time in minutes needed for effective decortications in each of the weights of Magadi soda was recorded. Corresponding pH's of the solutions at each of these weights of the Magadi soda were also measured using a calibrated digital pH meter (model-PHS-3B) at room temperature. To ensure the optimization of the process, the least-weight Magadi soda that decorticated in the shortest time possible was taken, which was then used in the actual treatment of the contaminated sample.

Decortication by Boiling in Magadi Soda Solution

Before boiling in the Magadi soda solution, the initial aflatoxin content of the sample was analyzed, 250g was weighed, washed in water to remove surface dirt and then mixed with the weight of the Magadi soda which resulted in the least time as in the pretrial process. Three quarter liter (750mls) of water was added to the mixture and then brought to a heat source to boil for the length of time corresponding to the weight that brought the least time of decortication. When it was ready, the mixture was washed serially four times in water where 500ml of water was used in each washing while being rubbed gently between the palms to remove the dissolved and loose pericarp. From the cleaned sample, 50g was taken for aflatoxin analysis. This process was done twice. The process for the control experiment was similar to the previous experiments except that for this treatment, the aflatoxin-contaminated sample was boiled in 750 ml of tap water without Magadi soda.

Decortication by boiling in maize cob ash

After the analysis of the initial aflatoxin content, 500g of this sample was admixed with the least amount of ash resulted in the shortest time of decortication as was obtained during the standardization step above. When the sample was ready, it was decorticated by rubbing off the pericarp between the palms and then rinsed serially in 4 liters of water with 1 liter in each rinse until the cleaning water became clear. The final aflatoxin was then measured.

Five hundred grams of the control sample was cooked in 1500ml of pure water for the length of time same as the one used for the ash-cooked sample and then washed 4 times in 1 liter of water per wash. The final aflatoxin content of the sample was then measured.

Wet pounding using mortar and pestle

After taking the initial level of aflatoxin, 2kgs of the maize was weighed and placed in a wooden pestle where it was sprinkled with 250ml of magadi soda solution (containing 150g of Magadi soda) and 250ml water as a control, without giving time to soak. The conditioned maize was then pounded on a mortar using a pestle where the pericarp chipped off through abrasion and impact. The decorticated maize was then dried briefly in cold air in the absence of light so as to allow easy separation of the pericarp from the decorticated

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

grains during winnowing. The final aflatoxin content of the sample after the treatment was then analyzed.

Machine decortications

After measuring the initial aflatoxin content of the contaminated maize, two kilograms of the sample was taken for de-hulling using maize de-huller (HNCL, China). The de-hulled sample was then passed through sample divider and homogenizer. Hundred grams of this sample was ground and tested for aflatoxin. The process was repeated thrice.

Solar irradiation

Moisture content of contaminated maize sample each 2kgs, was analyzed and then spread on a black plastic sheet of $1m^2$ to one layer thick in the open sunlight for 24 hours which was done in three phases of 6 hours a day. In each day, the sample was exposed to the sunlight for 6 hours, from 10 am to 4.00 pm preferably when the sun was bright. Aflatoxin content for the samples was taken after every 6 hours. This exposure to the bright sunlight was carried out when there was plenty of sunshine while the second experiment was carried out when it was partly cloudy. This was carried out to check how the aflatoxin reduction occurred in partial sunshine and in bright sunshine. The strength of the solar radiations for each of these days was obtained as average values of radiation per day from the solarimeter stationed at Jomo Kenyatta International Airport courtesy of Kenya Meteorological Department Headquarters, Nairobi. This was to ascertain the relationship between the strength of the solar radiations [affected by the cloud cover (insulation)] and the time of exposure with the loss of aflatoxin.

Statistical Analysis

Data showing the final aflatoxin content for maize exposed to the different treatments were subjected to one-way ANOVA using Genstat® Discovery 13^{th} Edition at a 95% confidence interval ($P \leq 0.05$). Variable means for measurements showing significant differences in the ANOVA were compared using the LSD. Values were judged to be significantly different by LSD if $P < 0.05$.

RESULTS AND DISCUSSION

Cooking in Magadi soda (Pretrial process)

The change in the pH of the solution with the increase in the concentration of Magadi soda is shown in Table 1. It also shows how the concentration of dissolved Magadi soda affects the amount of time needed for effective decortication.

Table 1. The relationship between the concentration of Magadi soda, pH change and the time needed for effective decortications

Weight of Magadi Soda(g/l)	*pH of solution	*Time taken for effective decortications(mins)
33.3	9.9 ± 0.2^a	50.5 ± 0.7^a
66.7	10.0 ± 0.1^a	42.0 ± 1.4^b
100.0	10.1 ± 0.1^a	33.0 ± 1.4^c
133.3	10.2 ± 0.3^a	33.5 ± 0.7^c

Figures with the same superscript in the pH column are not significantly different (p=0.539) and for time column (p<0.001) ***(mean ± SD), N=3**

Increasing the concentration of the Magadi soda did not cause significant change in the pH of the solution ($P \leq 0.05$). The highest pH attained at the highest concentration of the Magadi soda of 133.3g/ litre did not differ significantly from the lowest pH attained with the lowest concentration of 33.3g/liter. Nevertheless, Magadi soda solution exhibits alkaline properties and that is why it has found its use in the softening of the pericarp of cereal and legume grains such as sorghum, millet, maize and beans so that they can be cooked quickly (Muindi et al., 2006). When the concentration of Magadi soda was increased from 33.3 g/litre to 100g/litre, the time needed to soften the pericarp reduced significantly from 50.5±0.7 to 33.3±1.4 minutes (Table 1). Concentration of

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Magadi soda at 100g/litre of water was therefore found to be the optimum for effective decortications of 250g of maize as it resulted in the least time. This ratio combination would be recommended for decortication.

Decortication using maize cob ash (pretrial process)

Maize cob ash was found to be strongly alkaline when dissolved in water as it exhibited pH above 11 from the first suspension containing 33.3g/l (Table 2). The pH continued to rise as more ash was added to the suspension. The pH of the ash suspension containing 33.3g of maize cob ash/liter of water was 11.6±0.7. There was no significant change in alkalinity when the amount of ash was increased to 50g/l. However, when the amount of ash was doubled to 100g, the pH increased significantly to 12.0±0.0 and increased further to 12.5±0.1 when the ash was raised to 133.3g/litre but this time not significantly.

Table 2. The relationship between the amounts of maize cob ash in water, the pH values, the time for effective decortication and the color of decorticated kernel

Weight of maize cob ash in g/l of water	*pH of solution	*Time for effective decortications(minutes)	Texture and color of the decorticated kernels
33.3	11.6 ± 0.7^{a}	49.7 ± 1.5^{a}	Soft and darkly colored orange
50.0	11.7 ± 0.1^{a}	39.3 ± 2.1^{b}	Slightly soft and slightly orange
100.0	12.0 ± 0.0^{b}	25.3 ± 0.6^{c}	Hard and colored bright yellow
133.3	12.5 ± 0.1^{c}	19.0 ± 1.0^{d}	Hard, bright and creamy yellow

Figures with the same superscript in a column are not significantly different ($p \leq 0.001$) ***(mean ± SD), N=3**

The time needed for effective decortication decreased significantly ($p<0.001$) as the amount of ash was increased. The time needed for effective decortication was 49.7±1.5minutes with 33.3g/l of ash. When the amount of ash was increased to 50g, the time needed for effective decortication reduced to 39.3 ±2.1 minutes even though the pH did not change. As the amount of ash was increased to 100g, the time needed for effective decortication reduced to 25.3±0.6 minutes. When the amount of ash dissolved is increased to 133.3g, the time needed for effective decortication is reduced to 19.0 ±1.0 minutes. When using maize cob ash, the lesser the amount of ash in the solution, the longer the time needed for effective decortication and vice versa.

Table 2 also shows the color of the decorticated maize associated with different levels of ash. When maize kernels are cooked in alkaline solutions, a yellowish orange color develops. The intensity of the color developed is affected by the concentration and the length of cooking. In this experiment, when less ash was used the time required to decorticate the maize increased. This resulted in the softening of the kernel due to overcooking and hence more penetration of the ash into it. Increased penetration of ash into the kernel makes the ash harder to rinse off. This leads to undesirable change in the flavor (soapy) and darkening of the endosperm. Using higher amount of ash on the other hand resulted in brightly colored and hard kernel because the cooking time is short and does not cause undesirable softening of the kernel. This results in less penetration of ash into the endosperm making it easier to rinse off.

Using 133.3g of ash/liter of water resulted in the shortest time needed for effective decortication i.e. 19 ± 1.0 minutes and has the highest pH value of 12.5 ± 0.1 which is strongly alkaline. This is the most optimum point in decortication using maize cob ash solution. This weight of ash and cooking time combinations were recommended as a standard procedure. Higher ratios of ash to water more than 133.3g effects higher pH can be considered uneconomical in the use of ash. In addition to this, the suspension becomes too thick to boil and sticks onto the pan as was noted during the experiment. Lower levels of ash change the palatability and the resulting color of the decorticated kernels.

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Effect of cooking of contaminated maize in maize cob ash and Magadi soda solutions on aflatoxin levels

The effect of cooking with Magadi soda and maize cob ash infusion on aflatoxin levels are shown in Table 3 in comparison with the control samples which were boiled in pure water. Boiling of the contaminated grains in Magadi soda led to a significant decrease in the level of aflatoxin from 59.5±3.8ppb to 13.4±0.4ppb. This translates to a loss of 77.5%. On the other hand, the loss of aflatoxin in the control sample was from 59.5±3.8ppb to 44.1±0.3ppb, which is 25.9%.

Table 3. The effect of boiling contaminated maize in the Maize cob ash and Magadi soda solution on the final aflatoxin levels

		Control (water)		Alkaline cooked	
Cooking Medium	***Initial Aflatoxin(ppb)**	***Final Aflatoxin(ppb)**	**Percent Drop**	***Final Aflatoxin(ppb)**	**Percent drop**
Magadi Soda(100g/l)	59.5 ± 3.8^{a}	44.1 ± 0.3^{b}	25.9	13.4 ± 0.4^{c}	77.5
Maize cob ash(133.3g/l)	83.1 ± 0.3^{a}	40.2 ± 0.3^{b}	51.6	7.0 ± 3.9^{c}	91.6

Figures with the same superscript in Magadi soda and maize cob ash cooking row are not significantly different ($p<0.001$), LSD=7.155 and7.183 respectively. ***(mean ± SD), N=3**

Boiling of the sample in the maize cob ash solution led to a significant decrease in the amount of aflatoxin from 83.1±0.3ppb to 7.0±3.9ppb which is a loss of 91.6%. Boiling of the same sample in water (control) led to decrease of aflatoxin from 83.1±0.3ppb to 40.2±0.3ppb which is a loss of 51.6%. When maize kernels were cooked in Magadi soda and maize cob ash solutions to effect decortication, the loss of aflatoxin was probably partly due to alkali degradation and leaching of the aflatoxins into the wash waters because even in the absence of the two alkalis, there was significant aflatoxin loss as shown by the control samples. Boiling of contaminated maize reduces aflatoxin to a considerable extent (Reddy et al, 2002). The difference in the aflatoxin loss between the samples boiled in water (control) and the alkali cooked samples can be accounted for by the action of these alkalis on aflatoxin. Alkalis are capable of disrupting the lactone ring of the aflatoxins when exposed to it (Joan and Alfredo, 2005). The aflatoxin lost during the cooking process could also be attributed to high temperatures used. High temperatures lead to ring opening followed by decarboxylation and reaction may proceed further, leading to the loss of the methoxy group from the aromatic ring (Anjum et al, 2022).

Use of other alkalis like wood ash and calcium hydroxide in the nixtamalization of maize for tortillas by Mexicans also led to decrease of aflatoxins significantly Mendez -Albores et al 2004. The difference however between the Mexican corn nixtamalization and the traditional process as is practiced by some Kenyan communities is that in the latter, there is no steeping of maize in the alkali. Boiling is done directly because steeping led to deep discoloration of the endosperm which was undesirable as it increased residual alkali in the endosperm and hence alteration of the kernel flavor when cooked (Zahra and Ejaz, 2012). When Magadi soda and maize cob ash were compared in their ability to bring down aflatoxin content in the contaminated samples during the alkali cooking, maize cob ash was proven to be more effective than Magadi soda. Maize cob ash reduced aflatoxin levels to below the maximum allowable limit of 10ppb (KS EAS 2:2000) from 83.1ppb to 7ppb. Magadi soda reduced the levels of aflatoxin to 13.4ppb which is very close to the tolerance level of 10ppb. During cooking for consumption, it is possible that the levels would fall below the tolerance.

Dry mechanical dehulling by milling and wet dehulling by mortar and pestle

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Table 4 shows how wet dehulling by pounding using Magadi soda solution, pure water (control) and machine dehulling using convectional Posho mill affect the level of aflatoxin in de-hulled maize. Aflatoxin levels are expressed on dry weight basis.

Table 4. Effect of wet and dry dehulling on final aflatoxin levels

	*Initial aflatoxin level (ppb)	*Final aflatoxin level(ppb)		
Decortication type		**Control**	**Magadi/machine**	**Percentage drop in aflatoxin**
Wet	81.5 ± 0.3^{a}	80.2 ± 0.2^{b}	72.7 ± 0.2^{c}	10.8
Dry	51.3 ± 15.3^{a}	n.a	9.6 ± 0.8^{b}	81.3

Figures of the same superscript in a row are not significantly different for wet decortication and dry decortication ($p<0.001$, LSD=0.7576 and $p=0.063$, LSD=47.17) ***(Mean ± SD), N=3**

Decortication of contaminated maize containing 81.5 ppb of aflatoxin in the presence of Magadi soda reduced the aflatoxin level by 10.8 %. On the other hand, doing decortication using pure water (control) reduces aflatoxin by 1.6% which shows that pounding maize with Magadi soda solution at room temperature affects reduction of aflatoxin to small extent. This is a small change compared to boiling in Magadi soda to remove the pericarp (Table 3), where heat catalyzed the breakdown of aflatoxin. Though the final aflatoxin level in both cases are statistically different from the initial one, this change is still far above the minimum level of aflatoxin as set by the East African Maize Standard (10 ppb). This agrees with the results (Mutungi, 2006) which showed that pounding of the contaminated maize soaked in Magadi did not reduce aflatoxin by a significant level. The aflatoxin reduction is however slightly greater with the use of Magadi soda than in control which showed that there was alkaline deactivation of aflatoxin.

Machine decortication of contaminated maize with aflatoxin level of 51.3ppb reduced the toxin level by 81.3% to 9.6 ppb which is below the minimum tolerance level set by the East African Standard which is 10ppb. The drop of the aflatoxin levels in the contaminated maize during dry dehulling agrees with the findings of similar research done before. Dehulling maize grains and wheat could reduce aflatoxin contamination by up to 92% and 95% respectively (Siwela et al., 2005). In this case, artificially contaminated maize was used during the research as opposed to naturally contaminated as one used in this experiment, which could be the reason for the slight difference in the drop of aflatoxin levels between these findings and theirs. In artificially contaminated maize, all aflatoxins would almost be found topically and hence easily removed by dehulling.

During dry dehulling all the aflatoxins which are found at the peripherals are removed with bran and part of the aleurone layer. These aflatoxins do not have a chance to diffuse to other parts of the kernel. The remaining percentage could be found deeper in the endosperm and at the germ as this process does not de-germinate. In wet dehulling, water provides a medium for the dissolution and diffusion of aflatoxin to other grains and other parts of the grain.

Solar irradiation

Tables 5a and 5b show the relationship between solar irradiation and the time of exposure on the level of aflatoxin during bright sunshine and partial sunshine respectively. During the process, in the first test when there was bright sunshine, the exposure to the sunlight for the first 6 hours at radiation of 27.4MJ/M^2 reduced the total aflatoxin content from 62.1±1.0 to 16.7±0.4 ppb which is 73.1% reduction. Additional exposure to sunlight for another 6 hours at a radiation of 26.2MJ/M^2 caused further drop of aflatoxin content from 16.7 ± 0.4ppb to 13.6±0.1ppb, (78.1%) reduction. Further exposure for additional 6 hours did not result in further change.

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Table 5a. Relationship between time of exposure to the sunshine and the aflatoxin level during bright sunshine

Time(hrs) of exposure	Average solarimeter reading (MJ/M^2)	*Aflatoxin content(ppb)	Percentage drop in aflatoxin
0	0	62.1 ± 1.0^a	0
6	27.4	16.7 ± 0.4^b	73.1
12	26.2	13.6 ± 0.1^c	78.1
18	26	13.8 ± 0.6^c	77.8

Figures with the same superscript in the final aflatoxin column are not significantly different ($p<0.01$, LSD=3.501) ***(mean ± SD), N=3**

NB: the initial aflatoxin content of each subsequent phase is the final aflatoxin content of previous phase. Initial aflatoxin at time zero (0) is the aflatoxin content during the beginning of the experiment.

In the second experiment (Table 5b) which was done in partially cloudy weather, the first 6 hours of exposure at a radiation value of 23.3 MJ/M^2 caused the total aflatoxins to drop significantly from 59.5±0.1ppb to16.3±0.4ppb which is a percentage drop of 72.6%. Further exposure to radiation of 23.53 MJ/M^2 for further 6 hours did not cause significant drop in the level of aflatoxin at $p<0.001$. However, when the amount of radiation is increased to 26.1 MJ/M^2, the aflatoxin levels dropped significantly from 16.3±0.6 ppb to13.6±0.8 ppb which is a drop of 77.1%.

Table 5b. Relationship between time of exposure and the aflatoxin level during partial sunshine

Time (hrs) of exposure	Average solarimeter reading (MJ/M^2)	*Aflatoxin content(ppb)	Percentage drop in aflatoxin
0	0	59.5 ± 0.1^a	0
6	23.3	16.3 ± 0.4^b	72.6
12	23.5	16.3 ± 0.6^b	72.6
18	26.1	13.6 ± 0.8^c	77.1

Figures with the same superscript in the final aflatoxin column are not significantly different ($p<0.001$) ***(mean ± SD), N=3**

The two experiments carried out in bright and partial sunshine proved that the drop of aflatoxin in the contaminated maize was being affected by the strength radiations from the sun which was affected by the cloud cover. Where the radiations were stronger, the reduction of aflatoxin was higher on exposure to the sunlight (Table 5a) as compared to where strength of radiations was lower (Table 5b). It was also proven that the loss of aflatoxin in whole maize was significant in the first 6 hours and thereafter, further exposure caused very small or no change in aflatoxin levels. Though it reduced, aflatoxin in maize kernels could not be destroyed completely by the sunlight.

In whole grains, the destruction of aflatoxin by the sunlight could be limited by the size of the grains since a similar experiment done using ground-contaminated animal feed showed that aflatoxin was almost completely destroyed when exposed to the sunlight. In this experiment however, the strength of the solar radiation was not measured (Gowda et al., 2005). The reason why aflatoxin could not be destroyed completely in whole kernels could be because in whole maize grain, aflatoxin can be found in the inner parts of the kernels. Fractions of the contaminated maize kernels showed that aflatoxin was present in each one of them though in different levels. The bran had the highest aflatoxin levels as compared to the endosperm (Miren et al., 2008). Considering its size, it therefore becomes very difficult for the sun's radiations to penetrate deeper parts of the kernel where aflatoxin could be embedded and hence the constant level of aflatoxin despite increased time of exposure to the sunlight.

CONCLUSION AND RECOMMENDATIONS

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Aflatoxin reduction was highest when contaminated maize was boiled in maize cob ash solution, whereas the least reduction was noticed with the exposure to the UV light. Studies need to be done to confirm the fate of aflatoxins when two or more of the treatments are combined in contaminated maize.

ACKNOWLEDGEMENT

Special thanks to the management of National cereals and Produce Board, Kenya for the financial and technical support during the course of this research

REFERENCES

Aflatoxin Content in Compounded Feed. Indian Journal of Animal Nutrition 22, 132-134

Anjum, T., Iram, W., Iqbal, M., Abbas, M., Akram, W., & Li, G. (2022). Structure elucidation and toxicity analysis of the byproducts formed after biodegradation of aflatoxins B1 and B2 using extracts of mentha arvensis. *Toxins*, *14*(1), 24.

A.O.A.C (2005). *Official methods of analysis.* Association of Official Analytical Chemists International, 967.08. Maryland, USA.

Bora Biotech® Limited (2009). Testing For Aflatoxins in Foods Manual, pg 9-14.

Domer, J. W. (2004). Biological control of aflatoxin contamination of crops [J]. *Toxin Reviews*, *23*(2), 425-450.

Gowda, N. K. S.1, Malathi, V., Suganthi, R. U., Raghavendra, A, (2005). Effect of Dry Heat and Sunlight on the Aflatoxin Content in Compounded Feed. Indian Journal of Animal Nutrition 22, 132-134.

Hell, K., & Mutegi, C. (2011). Aflatoxin Control and Prevention Strategies in Key Crops of Sub-Saharan Africa. African Journal of Microbiology Research, 5(5), 459-466.

IFPRI (2011). New Study Documents Spread of Aflatoxins In Kenya. Press release, January 13, 2011. Cited on www.ifpri.org

Joan, M. K., and Alfredo, D. P., (2005). Chemical Detoxification of Aflatoxin in feeds and foods. Journal of aflatoxin and food safety 26, 543-553.

KEBS (2008). Cereals and Pulses as Grain-Methods of Sampling, KS EAS 79:1999, pg2

Marshall, H., Meneely, J. P., Quinn, B., Zhao, Y., Bourke, P., Gilmore, B. F., ... & Elliott, C. T. (2020). Novel decontamination approaches and their potential application for post-harvest aflatoxin control. *Trends in Food Science & Technology*, *106*, 489-496.

Méndez-Albores, J. A., Arámbula-Villa, G., Loarca-Piña M. G., González-Hernández J., Castaño-Tostado, E., & Moreno-Martínez, E. (2004). Aflatoxins' Fate during the Nixtamalization of Contaminated Maize by Two Tortilla-Making Processes. Journal of Stored Products Research, 40(1), 87-94.

Miren C., Sonia M., Vincente S., Antonio J.R., (2008). Distribution of Fumonisins and Aflatoxins in Corn Factions during Industrial Cornflake Processing. International Journal of Food Microbiology. Volume 123, Issues 1-2, 81-87.

Muindi, P.J., Thomke, S., Ekman, R. (2006). Effect of Magadi Soda Treatment on the Tannin Content and In-Vitro Nutritive Value of Grain Sorghums. J. Sci. Food Agric. 32(1): 25-34.

Mutungi, C. M. (2006). Effects of Dehulling Maize Grains and Treatment with Chemical Additives on the Levels of Aflatoxins during Muthokoi Making and Preparation. http://erepository.uonbi.ac.ke:8080/xmlui/handle/123456789/19182.

Reddy, S.V. and Farid, W. (2002). Aspergillus and Aflatoxin in Groundnut; Properties of Aflatoxin and Its Producing Fungi. International Crop Research Institute of Semi-Arid Tropics.

Reddy, K. R. N., Raghavender, C. R., Salleh, B., Reddy, C. S., & Reddy, B. N. (2011).

Article DOI : https://doi.org/10.37284/eajab.7.1.2097

Potential of aflatoxin B1 production by Aspergillus flavus strains on commercially important food grains. *International journal of food science & technology*, *46*(1), 161-165.

Sipos, P., Peles, F., Brassó, D. L., Béri, B., Pusztahelyi, T., Pócsi, I., & Győri, Z. (2021). Physical and chemical methods for reduction in aflatoxin content of feed and food. *Toxins*, *13*(3), 204.

Pitt, J. I., Marta H. Taniwaki, and M. B. Cole. "Mycotoxin production in major crops as influenced by growing, harvesting, storage and processing, with emphasis on the achievement of Food Safety Objectives." *Food control* 32.1 (2013): 205-215.

Siwela, A.H., Siwela, M., Matindi, G., Dube, S., Nziramasanga N. (2005). Decontamination of Aflatoxin-Contaminated Maize by Dehulling. Journal of the Science of Food and Agriculture 85: 2535-2538.

WHO, 2015. WHO estimates of the global burden of foodborne diseases: Foodborne disease burden epidemiology reference group 2007-2015. World Health Organization.

Williams, J. H., Phillips, T. D., Jolly, P. E., Stiles, J. K., Jolly, C. M., &Aggarwal, D. (2004). Human Aflatoxicosis in Developing Countries: A Review of Toxicology, Exposure, Potential Health Consequences and Interventions. American Journal of Clinical Nutrition, 80(5), 1106-1122.

Zahra, N., Hina, S., & Ejaz, N. (2012). Detoxification of Aflatoxin B1 in Poultry and Fish Feed by Various Chemicals: Poultry and Fish Feed Detoxification. *Biological Sciences-PJSIR*, *55*(3), 154-158.

