Sustainable Cashew & Peanut Small Business

AMCANE project

Aflatoxin Prevalence Study

tanager
an ACDI/VOCA affiliate

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1. Introduction

Background

The Sustainable Cashew & Peanut Small Business project (hereafter “AMCANE”) is implemented through a public-private partnership between HELVETAS Swiss Intercooperation, the Aga Khan Foundation and PAKKA AG. The overall goal of the project is to increase the sustainability of production systems, foster livelihoods of smallholder farmers and small entrepreneurs, and to enhance the availability of nutritious food of good quality in Northern Mozambique (Cabo Delago and Nampula province).

A priority focus of the project is the improved management and control of aflatoxin in the peanut value chain. The project aims to identify the prevalence of aflatoxin in peanuts produced in project intervention zones and to analyze the main causes of aflatoxin contamination at crucial stages of the peanut production and post-harvest cycle. The results of this research will help to then identify locally adapted solutions to minimize mycotoxin contents in the peanut value chain. Furthermore, the evidence created by the project shall be used to inform decision makers in Mozambique on how to address this urgent health issue at the policy level, and will propose solutions to peanut market actors on how to manage aflatoxin in their products.

Aflatoxin Management

Prevention or management of aflatoxin contamination may be directed at both the process of contamination and the fungi causing the contamination. The contamination process can be divided into two phases based on crop maturity. The first phase occurs during crop development and is generally associated with physical damage to the crop, typically by either physiologic stress or insect activity. Crop components contaminated during the first phase often fluoresce a bright green-yellow as a result of kojic acid production in crop tissue by the aflatoxin-producing fungi.

After maturation, crops remain vulnerable to contamination, providing a window during which a second phase of contamination may occur. Exposure of the mature crop to both high humidity and temperatures conducive to aflatoxin producing fungi can result in both new crop infections and increases in the aflatoxin content of crop components already infected. The second phase may occur prior to harvest in the field or after harvest during transportation, storage, or at any point until the crop is consumed.

Hot dry conditions during crop development favor the first phase of contamination, whereas rain and high humidity with warm temperatures after crop maturation favor the second phase. Reliable management practices must address both phases. Improving the resistance of cultivars to contamination is one method of simultaneously addressing both phases of contamination. Although proper cultivar selection and crop management can limit vulnerability to both phases, environmental changes can frustrate even the best management practices and result in a highly contaminated crop.

Most important, pre-harvest factors that lead to aflatoxin contamination in peanuts:

1. Drought stress (in particular 4 to 6 weeks before harvest)

High temperatures and low atmospheric humidity associated with drought stress favor the growth of aflatoxin producing fungi (e.g. through increased soil temperature) while suppressing the growth of other microbes and giving a competitive advantage to the aflatoxin-producing fungi.

If kernel moisture (kernel water activity) is maintained until harvest, the plant can fight off fungal colonization and subsequent aflatoxin production through its own with natural defense mechanisms. Exception: High insect pressure and extensive pod damage give an advantage to the fungus due to plant stress accompanied by a decrease in plant immunity.

2. Peanut carbohydrate levels

Immature and drought-stressed peanuts are reported to have greater carbohydrate (sugar) levels than mature, non-stressed seed. Aflatoxin-producing fungi grow faster on high sugar substrates. Thus, greater carbohydrate levels are linked to increased aflatoxin development in peanuts.

3. Soil calcium content

Calcium deficiency leads to increased aflatoxin accumulation.

Peanut yield has long been known to be substantially affected by calcium soil levels. While calcium requirements vary with pod development, calcium plays an important role in cellular structural functions, regulating membrane permeability and strengthening cell walls. In peanuts, calcium is absorbed directly by the developing pod from the soil. Drought limits calcium uptake.

4. Soil arthropods

Insects may damage pods, destroy roots, or cause pod scarification. Examples of such soil arthropods include: White grubs (Coleoptera: Scarabeidae), millipedes (Myriapoda: Diplopoda), symphilids (Myriapoda: Symphyla), termites (Isoptera: Termitidae), earwigs (Dermaptera: Forficulidae), wireworms (Coleoptera: Elateridae), red ants (Hymenoptera: Formicidae), mealybugs (Homoptera: Pseudoccoccidae), black ants (Hymenoptera: Formicidae), centipedes (Myriapoda: Chilopoda).

Most important post-harvest factors that lead to aflatoxin contamination:

1. Pod damage

The greatest protection of peanuts against fungal contamination is a healthy, undamaged pod. **Any kind of damage to the pod will significantly increase the chance of aflatoxin contaminated peanuts within the pod.** This is due to the fact that fungal spores can gain entrance through (micro and macro) cracks and holes, propagate on the inside of the pod, and result in spoiled nuts (discolored, shriveled, moldy).

2. Pod Moisture content

It is essential that pods and nuts are dried properly. High moisture content, especially during storage, promotes fungal and subsequently aflatoxin development.

3. Post-harvest insects

Chewing insects will cause damage to the pod and provide entry for fungal spores. Aflatoxin can develop at any point in the handling chain.

Study Objectives

The objectives of this research are

I. The **prevalence of aflatoxin in peanuts** in three districts of Cabo Delgado and Nampula provinces is measured, analyzed and compared, based on samples from representative smallholder farmers.
II. To assess the aflatoxin contents of peanuts at 3 critical stages in the post-harvest cycle are measured and compared (harvest; threshing, 4 weeks post-harvest; drying and storage, 8 weeks post-harvest), in order to analyze **changes of aflatoxin levels along the value chain**.
III. Based on I. and II, **key factors contributing to aflatoxin contamination** in the peanut value chain are identified and related to relevant production and postharvest practices.
IV. Recommendations for **possible measures and technical solutions** to control aflatoxin contents (practices, technologies) are provided.

The goal of this research is:

I. To identify **key factors contributing to aflatoxin contamination** in the peanut value chain
II. To formulate recommendations for **possible measures and technical solutions** to control aflatoxin contents (practices, technologies)

2. Key Results

Prevalence study

- Aflatoxin is a persistent problem in the studied areas and was detected on each farm in each district.
- Acceptable samples: from the 60 samples, 35 samples (58%) were below 4ppb (regulatory limit EU), 37 samples (62%) were below 10ppb (regulatory limit Mozambique), and 41 samples (68%) were below 20ppb (regulatory limit USA).
- Market rejection and health danger: 23 samples (38%) were above 10ppb, 19 samples (32%) were above 20ppb, 12 samples (20%) were above 100ppb and 6 samples (10%) were above 300ppb.
- Aflatoxin contamination did not cluster in districts or individual villages. Villages had both high and low aflatoxin contamination.
- Contrast analysis showed that Meconta had significantly more samples contaminated with >1ppb total aflatoxin than Chiure and Mogovola but not Erati.
- Grading parameters in the prevalence study did not correlate with aflatoxin content.
- 15% of samples had moisture levels below 5.5%, 10% were above 10%. 75% of samples had moisture levels at or above 5.5%.
- Chiure (Cabo Delgado) has significantly more insect damage than Nampula Province.

Time-course development study:

- Aflatoxin contamination was dominant on all farms and all samples tested positive for aflatoxin.
- At harvest, all samples were below 2ppb (range 0.3 to 1.3ppb) and consequently fit for human consumption.
- Based on EU standards (4ppb): 80% and 53 % of samples were still fit for human consumption after 4 and 8 weeks after harvest, respectively.
- Based on Mozambique standards (10ppb): 80% and 60% were still fit for human consumption after 4 and 8 weeks after harvest, respectively.
- Based on US standards (20ppb): 87% and 67% of samples were still fit for human consumption after 4 and 8 weeks after harvest, respectively.
- ANOVA and contrast analysis showed a significant increase in aflatoxin contamination between 4 and 8 weeks post-harvest.
- Insect damage **significantly decreased** over time, which warrants further investigation.
- Overall pod damage and incidence of broken pods **significantly increased** over time showing that mishandling of the pods creates entry ways for the fungus.
- 8 weeks post-harvest, more than 50% of nuts contained in damaged pods were damaged.

Farmer Practices

- Nearly all farmers dry the harvested pods in piles on the ground in the fields for on average 14 days.
- 86% of farmers clean and sort the pods, removing damaged (in particular insect damaged pods).
- 40% shell immediately after drying the pods.
- 60% of farmers wait an average of 7 to 10 days before shelling their dried pods.
- No farmers dried the shelled nuts.

Key factors

Unfortunately, the analysis of the results from this year's investigation has not been able to identify one key risk area, which if addressed, would prevent aflatoxin development, as a number of factors are at play, including:

- Approximately 12% of pods were already damaged at harvest and approximately 50% of these pods were damaged by insects;
- Aflatoxin levels significantly increased from harvest to eight weeks, and aflatoxin levels continued to develop even though the moisture levels were on average below 6.6% after four weeks;
- Damage to the pods continued during storage, however the cause of the breakdown of the pods is unknown at this point – but the breakdown of the pods allows the aspergillus spores access to fertile growing material;

- The high levels of moisture and the poor drying conditions experienced this season may have been a contributing factor in the breakdown of the pods;
- Aflatoxin was found in peanuts from both good and bad nuts, and therefore the assumption is that what looked like good pods were actually damaged in ways which had allowed the *Aspergillus* fungus access.

3. Recommendations

1. Repeat the prevalence study in 2020
    a. Given the extraordinary weather in 2019, the results of this investigation may fall outside the results found in a more normal harvest season. Regardless, understanding the underlying risks to the peanut trade has been invaluable information to gather.
2. Repeat the post-harvest study in 2020
    a. Given the extraordinary weather in 2019, the results from this investigation may fall outside the results found in a more normal harvest season -- Understanding whether the damage to pods experienced in 2019 is normal or not will help to fine tune later post-harvest interventions.
3. Undertake pre-harvest investigations into the type of insects which are damaging the pods prior to harvest in AMCANE's intervention areas.
    a. Discovering the point at which the insects are damaging the forming pods, as well the type of insects which are the problem, will allow the project to identify suitable and affordable treatments.
    b. Further calculations regarding organic premiums and the required procedures are needed to better understand how to address pre-harvest damage to pods.
4. Given the low levels of aflatoxin at harvest and the practice of drying on the ground where the ease of *Aspergillus* spores coating the pods increases, the project should investigate the use of tarpaulins for drying.
    a. Note the use of tarpaulins by IFPRI in Kenya for maize drying has reduced the levels of aflatoxin found in dried maize.
5. West Africa has experimented with storing pods and peanuts in hermetic storage. The advantage is that hermetic storage arrests aflatoxin development and if the moisture levels when the material enters the bags are good, the quality of the product will be maintained. However, if the moisture levels of the material placed into the bags is too high, the nut quality can be ruined.
    a. Test the effectiveness of the current drying practices by monitoring the reduction in moisture over time using different methods.

        i. To test whether different drying methods influence aflatoxin development would be very hard, as it would require controlled experiment with fairly large volumes of peanuts. An alternative would be collecting samples from a large number of farmers, each using one drying method, however this may likely fall outside the project scope.
    b. Promote the drying methods which are demonstrated to be most effective
    c. Demonstrate the use of hermetic bags and test whether the Fair Average Quality (FAQ) of the nuts improves; if the quality of the resulting nuts improves, and the market provides a premium for this visual quality improvement, farmers would be motivated to adopt.
6. Given the low levels of aflatoxin at harvest, the use of bio controls on the field may not be economical, particularly until the post-harvest contamination through drying on the ground, storing in old contaminated bags etc. is addressed.
7. The levels of aflatoxin in good nuts from good pods was surprising. Undertaking a more detailed investigation into the aflatoxin levels of damaged pods (and the resulting good and bad nuts) and undamaged pods (the resulting good and bad nuts) may identify additional intervention points.
8. The incidence of broken pods increases significantly over time. As the pods dry, the damage becomes more pronounced as the pods pull apart as they dry. The cause of this damage, which could be due to handling, a weak pod shell, or actual insect damage, and the fact that becomes so severe that the pods look broken in week 8, should be investigated.

Provided the above, the below are some other recommendations to control aflatoxin content levels:

- General GAP management strategies relating to aflatoxin contamination should be put in place.
- Farmer awareness should be increased, in particular regarding the connection between damaged pods, aflatoxin, and the low number of nuts contained in damaged pods.

4. Detailed Findings: Prevalence Study

Aflatoxin prevalence in the studied locations

To assess aflatoxin prevalence, a 3kg sample was obtained from 60 farms located in four districts (Chiure, Erati, Meconta, Mogovola) roughly 4 weeks after harvest. Samples were transported to HELVETAS Headquarter in Nampula, graded for damage (see next section), and analyzed for aflatoxin content using the Neogen Reveal Q+ lateral flow system.

Aflatoxin content was analyzed by district (Chiure, Erati, Meconta, Mogovola) using the **G**eneralized **L**inear **M**odel (GLM) for ANOVA (**An**alysis **o**f **Va**riance) analysis (Table 1). The significance level was set at 0.05 (5% risk of concluding that an effect exists when there is no actual effect).

Aflatoxin contamination is a dominant problem in the studied areas. All samples (n=60) tested positive for aflatoxins:

- 33 samples were between 0.1 and 2ppb,
- 27 samples were above 2ppb,
- 23 samples were above 10ppb,
- 19 samples were above 20ppb,
- 13 samples were above 50ppb,
- 12 samples were above 100ppb,
- 6 samples were above 300ppb,
- 4 samples were above 400ppb
- 1 sample was at 901 total aflatoxin content.

Table 1 shows the range of aflatoxin contamination (total aflatoxins) and the percentage of samples above 1ppb by district.

Table 1: Range of aflatoxin levels and the percentage of samples above 1ppb by district

	Range of aflatoxin levels ppb	Percentage samples above 1ppb
Chiure	0.8 - 901	93
Erati	0.5 - 370	87
Meconat	1.2 - 445	100
Mogovola	0.6 - 471	67

The results from all farmers can be seen in Annex C, and a summary of the average aflatoxin values per location can be seen in Table 2.

Aflatoxin contamination did not cluster in certain locations or villages and seems to be a relatively homogeneous problem in the studied areas (Table 2). For example, the number of samples containing more than 100ppb was as followed: Chiure (n=4), Erati (n = 3), Mogovola (n=3), and Meconta (n=2). The sample with the highest aflatoxin content (901ppb) was found in Chiure (Village Mugipala). This was the only sample analyzed from this village. In each village (with at least two farmers sampled), at least one farmer had more than 40ppb total aflatoxin content. The only exception is Nkutehami in Mogovolas, where only three farmers were visited, and both had only up to 2ppb total aflatoxin content.

A visual overview of the aflatoxin prevalence in the studied villages is shown in Figure 1 and 2.[1]

Figure 1: Peanut Farmers in Erati[2]

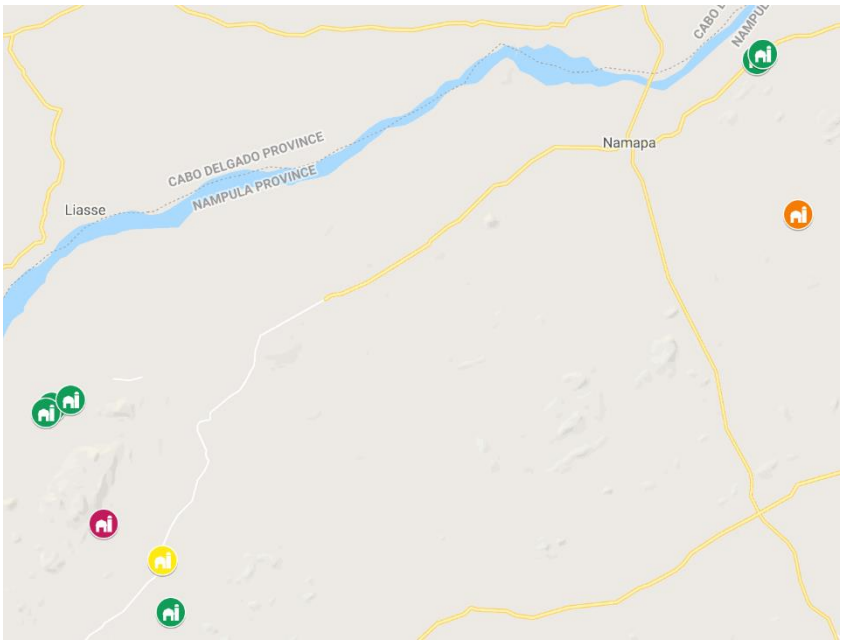
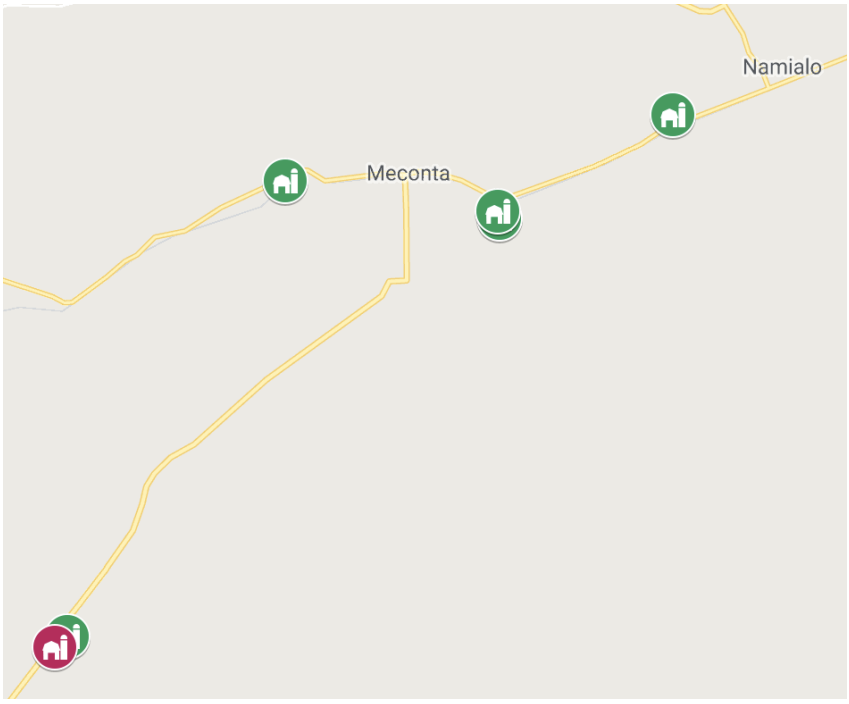


Figure 2: Peanut Farmers in Meconta



[1] A full map can be viewed online at https://drive.google.com/open?id=12lcVHYVT7LqvFpHGlWbog2InPlZV86jA&usp=sharing
[2] Color coding: Green indicates 0.1 - 4ppb; yellow indicates 4.1 - 20ppb; orange indicates 20.1-50ppb; red indicates anything over 50ppb.

Pod damage in the studied locations

The 3kg sample was graded based on the following pod damage categories: broken pods (mechanical damage); pods with visible insect damage; and pods with visible discoloration and/or mold infestation. Since mold infestation and discoloration occurred virtually simultaneously, these two categories were combined. Additionally, the number of empty pods was assessed in the damaged proportion of the 3kg sample. The total proportion of damaged pods (Damaged pods = broken pods plus insect damage plus mold/discoloration) was calculated for each sample:

Damage incidence in complete sample (%) = (Number of all damaged pods/Total number of all pods)*100

Also, to assess if any damage category was more prevalent than another, the incidence of individual damage within the damaged proportion of the sample and the total 3kg sample was calculated, e.g.

Insect Damage incidence in damaged proportion of sample (%) = (Number of insect damaged pods/Total number of damaged pods)*100

Insect Damage incidence in complete sample (%) = (Number of insect damaged pods/Total number of all pods)*100

Incidence of damage was analyzed by district (Chiure, Erati, Meconta, Mogovola) using the **G**eneralized **L**inear **M**odel (GLM) for ANOVA (**An**alysis **o**f **Va**riance) analysis (Table 2). The significance level was set at 0.05 (5% risk of concluding that an effect exists when there is no actual effect).

- The damage incidence ranged from 2 to 32% (average of 12%).
- For more than half of the farms (53%), at least 10% of pods were damaged.
- Eight farms (13%), five of which were located in Chiure, had more than 20% of their pods damaged.
- In general, with an average of 17.4%, Chiure had an above average amount of damaged pods per sample (Table 2 and Table 3).
- Mold and discoloration were the greatest problem for farmers. On average, 7% of the crop showed this damage (range 1.3 to 20.3%) (Table 2 and Table 5).
- This was followed by insect damage (average 3.5%) and broken pods (average 2.0%). However, sorting and grading has some bias, since mold covered pods may also have insect damage which is not apparent anymore (holes might be overgrown with fungal mycelium). So grading should be viewed as a trend and not as an absolute.

Within the damaged proportion of the sample, insect damage was also a big factor. In 18 samples (30%), 33% or more of pod damage was caused by insects. On 51 farms (85%) more than 10% of the damaged pods were damaged by insects. Insect damage and fungal growth are inevitably connected. Pods stored with holes, but no sign of mold, can be visibly contaminated within days (under favorable environmental conditions such as high humidity and temperature). Fungal spores are present on the outside of the pods, in the dust and air and easily translocated to storage rooms. Controlling storage pests and removing damaged pods prior to storage is necessary to mitigate further fungal contamination during storage.

Additionally, the highest occurrence of empty pods was found in samples with the high insect damage (45% or more). This is not surprising, since the highly nutritious, developing peanut is a favored food source for soil and other arthropods.

Chiure had a statistically significant higher incidence of insect damaged pods in both the complete 3kg sample (Table 2) and the damaged proportion of the sample (Table 3) than other districts. Consequently, the average aflatoxin content in the samples was higher than in the other districts, but not significantly. It is recommended to identify the main insects attacking stored peanuts and to formulate insect control measures in Chiure.

Table 2: Summary by District: Aflatoxin content and damage in combined 3kg sample

Location	Average Aflatoxin (ppb)	Average Aflatoxin log	% Damaged pods	% Insect damaged pods	% Pods with mechanical damage (broken)	% Pods with mold or discoloration	% Bad nuts	% Empty pods
Chiure	118.6 a	2.8 a	17.3 a	6.7 a	2.5 a	8.1 a	10.2 a	3.1 a
Erati	52.8 a	2.3 a	11.9 a	3.1 b	1.4 a	7.4 a	7.4 a	2.5 a
Meconta	61.9 a	2.2 a	10.1 a	2.1 b	2.4 a	5.6 a	12.7 a	2.7 a
Mogovola	57.6 a	1.9 a	9.6 a	2.2 b	1.6 a	5.8 a	10.7 a	2.5 a

Results are averages of all samples per district. Values for a variable within a column followed by a common letter are not significantly different based on Tukey's HSD test (P= 0.05).

Table 3: Summary by District: Incidence of different damage in the damaged portion of the sample

Location	Average number of damaged pods in sample	% Insect damaged pods in damaged sample	% Pods with mechanical damage (broken) in damaged sample	% Pods with mold or discoloration in damaged sample	% Bad nuts found in bad pods	% Bad nuts found in good pods
Chiure	469 a	39.4 a	14.9 a	45.6 a	35.7 a	7.1 a
Erati	305 a	24.9 b	12.8 a	62.4 a	32.9 a	4.7 a
Meconta	352 a	22.0 b	23.3 a	54.7 a	32.3 a	11.0 a
Mogovola	321 a	23.1 b	17.3 a	59.6 a	36.6 a	9.0 a

Results are averages of all samples per district. Values for a variable within a column followed by a common letter are not significantly different based on Tukey's HSD test (P= 0.05).

Table 4: Average incidence of damage categories in the sample and within the damaged proportion of the sample

	Incidence (%)		
	Mold/Discoloration	Insect holes	Broken pods
Combined Sample	6.7	3.5	2.0
Damaged Proportion	55.6	27.3	17.1

Nut damage in the studied locations

After grading, pods were shelled. Damaged and undamaged pods were shelled individually to assess the number and weight of peanuts within each category. In general, peanuts were regarded as bad when they showed signs of discoloration, mold, shriveling or any other kind of atypical appearance. Peanuts were regarded as good if appearance was typical for the peanut at that specific stage of investigation (after harvest, storage, etc.). The number and weight of bad nuts in damaged (bad) pods and undamaged (good) pods was determined. As well as the number of good nuts from bad and good pods (Table 2, 3 and 4). In general, about one-third of bad nuts are found in bad pods. On average, within a sample a pod contained 1.8 nuts -- a good pod contained 2 nuts and a bad pod contained 0.8 nuts.

Results from a previous study currently unavailable for sharing have shown that bad pods also harbor a significant amount of aflatoxin. Information is lacking on the aflatoxin content of the good nuts found in bad pods. If damaged pods were removed, farmers would face a 10 to 20% loss of their harvest. Since these nuts are also poisonous to domestic animals (in particular birds), and the toxin is transferred via milk of lactating animals (cows), the damaged peanuts should not be used as animal feed. For a small scale farmer this trade off might not be feasible, especially since aflatoxin is an invisible danger, and aflatoxin mitigation programs, such as a combination of pest control, sorting, biocontrol, and proper drying and storage options, need to be established sustainably (i.e. the market needs to compensate farmers for the costs of supplying improved quality nuts). No single solution will lead to the needed success when combating aflatoxin's contagion effects – Multiple interventions at various stages need to be implemented.

It is important to note that due to Cyclone Kenneth and unusually heavy rains, the moisture content of peanuts may not be representative for a regular season; farmers reported that drying was more difficult this year. During this study, 75% of samples were above 5.5% moisture four weeks post-harvest.

Correlation analysis

Correlation analysis indicates **no** significant correlation between aflatoxin and grading variables. A very weak correlation was only found between (%) damaged pods in the sample and aflatoxin content ($r = 0.34540$), however, this can be interpreted as a trend but not as a statistically significant correlation. This result is unusual, since data from other countries show a relationship between damaged pods and aflatoxin contamination. Other factors leading to aflatoxin contamination in peanuts should be investigated discussed in recommendations.

Positive correlations were found between the incidence of damaged pods in the sample and the incidence of mold infestation and discoloration of pods, as well as the incidence of empty pods. Also, insect damage was positively correlated with the incidence of moldy and discolored pods ($r =0.78081$, $P>r <0.0001$). Insects will create holes in the pod through which fungi gain access. As a consequence, visible mold will appear, which is usually accompanied by discoloration through fungal metabolites.

A very strong correlation was found between the incidence of bad nuts in the sample and the incidence of bad nuts contained in good (undamaged) pods ($r =0.99181$, $P>r <0.0001$) indicating the overall number of bad nuts contained in healthy pods. Furthermore, these bad nuts are in terms of looks, and at this point there is no information on their aflatoxin levels. This is a somewhat unusual finding and needs further investigation. The pod strength of the common peanut varieties grown should be evaluated to see which ones are more prone to microcracking. Detailed results can be seen in Table 5.

Table 5: Correlation analysis – aflatoxins, grading parameters

	Aflatoxin (ppb)	Aflatoxin log	% damaged pods in sample	% Insect damaged pods in sample	% broken pods in sample	% Moldy/ Discolored pods in sample	% Moldy/ Discolored pods in damaged sample	% Empty Shell	% Bad nuts in sample	% Bad nuts in bad pods	% Bad nuts in good pods
Aflatoxin (ppb)	1	0.79466	0.34540	-0.17606	0.13535	0.39452	0.12689	0.10522	0.00794	0.18576	-0.01705
Aflatoxin-log	0.79466	1	0.32631	-0.06121	0.09407	0.27429	-0.00760	0.2020	-0.03773	0.17845	-0.06108
% Damaged pods in sample	0.34540	0.32631	1	0.17775	0.03182	0.76472	-0.06136	0.49043	-0.06422	0.12574	-0.11404
% Insect damaged pods in sample	-0.17606	-0.06121	0.17775	1	0.03182	-0.32723	0.78081	0.36960	0.25959	0.21146	0.23177
% Broken pods in sample	0.13535	0.09407	0.03182	0.03182	1	-0.43905	-0.55010	0.11145	0.03860	0.07081	0.04384
% Moldy/ Discolored pods in sample	0.39452	0.27429	0.76472	-0.32723	-0.43905	1	0.55046	0.16243	-0.12288	0.05846	-0.15165
% Moldy/ Discolored pods in damaged sample	0.12689	-0.00760	-0.06136	0.78081	-0.55010	0.55046	1	-0.38080	-0.24277	-0.22216	-0.22265
% Empty Shell	0.10522	0.2020	0.49043	0.36960	0.11145	0.16243	-0.38080	1	0.04255	0.44045	-0.01749
% Bad nuts in sample	0.00794	-0.03773	-0.06422	0.25959	0.03860	-0.12288	-0.24277	0.04255	1	0.27263	0.99181
% Bad nuts in bad pods	0.18576	0.17845	0.12574	0.21146	0.07081	0.05846	-0.22216	0.44045	0.27263	1	0.19962
% Bad nuts in good pods	-0.01705	-0.06108	-0.11404	0.23177	0.04384	-0.15165	-0.22265	-0.01749	0.99181	0.19962	1

Yellow highlighted are significant correlations at P>r <0.0001, grey highlighted are weak correlations.

Contrast analysis

Contrasts are used to test for differences among the levels of a factor, here aflatoxin content of samples in different districts. Contrasts were analyzed by district (Chiure = contrast 1, Erati = contrast 2, Meconta = contrast 3, Mogovola = contrast 4) using the **G**eneralized **L**inear **M**odel (GLM) procedure (Table 6). The significance level was set at 0.05.

Contrasts detected significant differences only for the district Mogovola compared to both Chiure and Meconta in the percentage of samples contaminated with aflatoxin over 1 ppb meaning Mogovola has significantly less samples contaminated with >1ppb total aflatoxin than Chiure and Meconta but not Erati (Table 6).

Table 6: Contrast of various handling stages. Depend variable: Aflatoxin samples >1ppb

Contrast: **Aflatoxin (ppb)**	DF	Contrast SS	Mean Square	F Value	Pr > F
1 vs. 2	1	0.03333333	0.03333333	0.31	0.5792
1 vs. 3	1	0.03333333	0.03333333	0.31	0.5792
1 vs. 4	1	0.53333333	0.53333333	4.98	0.0297
2 vs. 3	1	0.13333333	0.13333333	1.24	0.2694
2 vs. 4	1	0.30000000	0.30000000	2.80	0.0998
3 vs. 4	1	0.83333333	0.83333333	7.78	0.0072
1 vs. 2&3&4	1	0.08889244	0.08889244	0.83	0.3663
1 vs. & 3	1	0.00000000	0.00000000	0.00	1.00

Yellow highlighted are contrasts for which with significant differences are detected (at P>r <0.0001). Contrast 1 = District Chiure, Contrast 2 = District Erati, Contrast 3 = District Meconta, Contrast 4 = District Mogovola

5. Detailed Findings: Time-course development study

Aflatoxin development

Samples (3kg) were taken three times during the season from a participating farmer (n=15) in Erati and Meconta. At harvest, samples were taken by manually pulling out plants from the field. Sampling of the field was conducted in a randomized fashion. Plant parts were snipped off the pod manually right after pulling. Pods were weighed in the field and transported back to HELVETAS Headquarters for grading and aflatoxin analysis. Four weeks and eight weeks after harvest, farms were revisited, and samples were taken in a randomized fashion from the farmers' stored peanuts. Grading and aflatoxin analysis were conducted as described in the Prevalence Study. The objective was to monitor aflatoxin development on the farm and to relate aflatoxin with pod/nut damage.

Aflatoxin content (ppb) was less than 2ppb at harvest and all samples were fit for human consumption and or trade (Table 7) but were too wet to sell (50% moisture level). However, eight weeks after harvest, aflatoxin content had increased significantly.

Based on EU standards (4ppb): 80% and 53% of samples were still fit for human consumption after four and eight weeks after harvest, respectively.

Based on Mozambique standards (10ppb): 80% and 60% were still fit for human consumption after four and eight weeks after harvest, respectively.

Based on US standards (20ppb): 87% and 67% of samples were still fit for human consumption after four and eight weeks after harvest, respectively.

These results also indicate that aflatoxin contamination starts in the field but is predominantly a post-harvest problem in peanuts during the investigated season. Additionally, heavy rains resulting in difficulties drying the pods supported aflatoxin formation. *Aspergillus* is mainly a saprophytic fungus living on above ground plant tissue without harming the host. Intact pods, innate plant immunity, and the fact that they grow underground, protects peanuts from *Aspergillus* infestation. However, pre-harvest stress of the plant may start the contamination process in the field. Once removed from the soil, fungal spores endemic in soil and on plant tissues are spread easily through dust and air. Protecting the pods at this vulnerable state is one of the main goals when it comes to preventing aflatoxin contamination. Additionally, reducing the amount of aflatoxin-producing fungi in the field, mostly achieved through biological control agents (such as non-aflatoxin producing fungi pre-harvest or yeasts applied post-harvest), significantly decreases the chances of aflatoxin formation.

Post-harvest moisture levels and other points

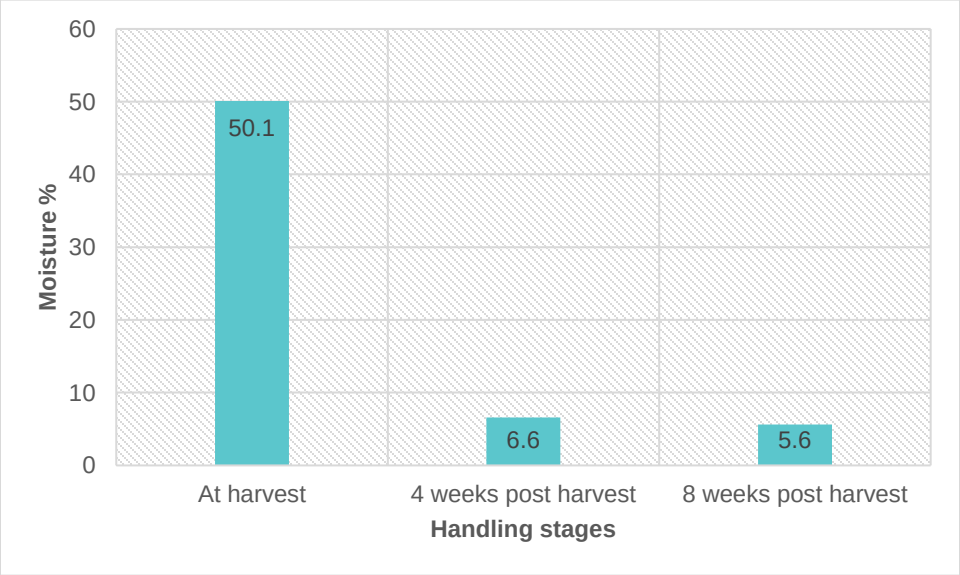
Moisture was significantly lower four and eight weeks after harvest (Table 7, Figure 3).

Table 7: Aflatoxin development and moisture content of peanuts on farm (Nampula Province)

Sampling stage	Aflatoxin (ppb)	Log Aflatoxin	Moisture
Harvest	1.2 a	0.7 b	50.1 a
4 weeks after harvest	14.2 a	1.6 ab	6.6 b
8 weeks after harvest	54.4 a	2.1 a	5.5 b

Results are averages of all samples (n=15). Values for a variable within a column followed by a common letter are not significantly different based on Tukey's HSD test (P= 0.05).

Figure 3: Moisture development of shelled peanuts at different stages during the handling chain. Moisture at harvest was significantly higher than the other stages (p = 0.005).



On average, within a sample each pod contained 1.8 nuts -- a good pod contained 2 nuts and a bad pod 0.8 nuts, indicating that damage to the pod decreases yields. This also implies the potential impact of insect infestation and the overall volumes available for sale. Approximately 60% of the weight of a sample was peanuts.

Damage development

Damage can occur at all stages of the post-harvest handling chain. Common harvest damage is insect damage (soil insects), primary mold infestation, and mechanical damage (broken pods). Mechanical damage is usually seen as a result of mechanized harvest and threshing. During storage, storage pests and secondary mold infestation can settle in.

Table 8 and 9 summarize the development of damage during the post-harvest handling chain. Overall, the total incidence damaged pods significantly increased eight weeks after harvest. Also, from all damage categories, the incidence of broken pods significantly increased while the incidence of insect damaged pods decreased. However, at this point it is not clear if broken pods might be a result of previous insect damage, i.e. pods might have been initially damaged by insects and developed bigger cracks during drying and storage which might be interpreted as mechanical damage. The reduction in insect damaged pods, as well as empty pods, could also be explained through sorting by the farmer.

Table 8: Summary by Handling Stage - Damage development on farm (Nampula Province)

Sampling stage	Log Aflatoxin	% damaged pods	% insect damage	% broken pods	% discolored/ moldy pods
Harvest	0.7 b	12.0 a	7.0 a	1.2 a	4.7 a
4 weeks after harvest	1.6 ab	12.8 a	2.9 ab	1.5 a	7.6 a
8 weeks after harvest	2.1 a	22.7 b	1.9 b	12.6 b	8.1 a

Results are averages of all samples (n=15) per handling stage. Values for a variable within a column followed by a common letter are not significantly different based on Tukey's HSD test (P= 0.05).

Table 9: Summary by Handling Stage - Incidence of different damage in the damaged portion of the sample

Sampling stage	Log Aflatoxin	% insect damage	% broken pods	% discolored/ moldy pods	% bad nuts in damaged pods	% Empty Pods
Harvest	0.7a	49.4 a	10.6 a	40.0 a	44.4 ab	23.8 a
4 weeks after harvest	1.6 ab	24.4 b	13.4 a	62.2 b	32.3 a	21.4 ab
8 weeks after harvest	2.1 b	11.2 b	41.6 b	47.2 ab	52.4 b	13.5 b

Results are averages of all samples (n=15) per handling stage. Values for a variable within a column followed by a common letter are not significantly different based on Tukey's HSD test (P= 0.05).

Contrast analysis

Contrasts are used to test for differences among the levels of a factor, here aflatoxin content of samples at different stages during the post-harvest handling chain. Contrasts were analyzed by stage of the post-

harvest handling chain (harvest = contrast 1, 4 weeks post-harvest = contrast 2, 8 weeks post-harvest = contrast 3) using the **G**eneralized **L**inear **M**odel (GLM) procedure (Tables 10-13). The significance level was set at 0.05. Dependent variables (factor) were: Total aflatoxin (ppb)(Table 10), Log aflatoxin (Table 11), Samples with aflatoxin content greater than 1ppb (Table 12), and Samples with aflatoxin content greater than 20ppb (Table 13).

Contrasts detected significant differences for total aflatoxin content of samples at harvest versus eight weeks post-harvest (Table 10) indicating a significant increase in aflatoxin contamination over time.

Table 10: Contrast of various handling stages (Depend variable: Aflatoxin (ppb))

Contrast: Aflatoxin (ppb)	DF	Contrast SS	Mean Square	F Value	Pr > F
1 vs. 2	1	1279.61883	1279.61883	0.31	0.5827
1 vs. 3	1	21228.39603	21228.39603	5.09	0.0294
2 vs. 3	1	12084.14700	12084.14700	2.90	0.0962
1 vs. 2 & 3	1	10977.29424	10977.29424	2.63	0.1124

Yellow highlighted are contrasts for which with significant differences are detected (at P>r <0.0001). Contrast 1 = harvest, Contrast 2 = 4 weeks post-harvest, Contrast 3 = 8 weeks post-harvest.

Contrasts detected significant differences for the log transformed aflatoxin content of samples at harvest versus eight weeks post-harvest and the combined four weeks and eight weeks after harvest (Table 11) supporting a significant increase in aflatoxin contamination over time, as already detected in Table 10.

Table 11: Contrast of various handling stages (Depend variable: Log Aflatoxin)

Contrast: Log Aflatoxin	DF	Contrast SS	Mean Square	F Value	Pr > F
1 vs. 2	1	5.98651754	5.98651754	3.09	0.0860
1 vs. 3	1	14.70756484	14.70756484	7.59	0.0086
2 vs. 3	1	1.92739968	1.92739968	0.99	0.3242
1 vs. 2 & 3	1	13.15358837	13.15358837	6.79	0.0126

Yellow highlighted are contrasts for which with significant differences are detected (at P>r <0.0001). Contrast 1 = harvest, Contrast 2 = 4 weeks post-harvest, Contrast 3 = 8 weeks post-harvest.

Contrasts detected significant differences for samples with an aflatoxin content greater than 1ppb at harvest versus four weeks post-harvest and the combined four weeks and eight weeks after harvest (Table 12) indicating the incidence of more samples with >1ppb over time.

Table 12: Contrast of various handling stages (Depend variable: Aflatoxin samples >1ppb)

Contrast: Aflatoxin samples >1ppb	DF	Contrast SS	Mean Square	F Value	Pr > F
1 vs. 2	1	1.63333333	1.63333333	9.03	0.0045
1 vs. 3	1	0.53333333	0.53333333	2.95	0.0934
2 vs. 3	1	0.30000000	0.30000000	1.66	0.2049
1 vs. 2 & 3	1	1.34444444	1.34444444	7.43	0.0093

Yellow highlighted are contrasts for which with significant differences are detected (at P>r <0.0001). Contrast 1 = harvest, Contrast 2 = 4 weeks post-harvest, Contrast 3 = 8 weeks post-harvest.

Contrasts detected significant differences for samples with an aflatoxin content greater than 1ppb at harvest versus four weeks post-harvest and the combined four weeks and eight weeks after harvest (Table 13) indicating the incidence of more samples with >20ppb eight weeks post-harvest.

Table 13: Contrast of various handling stages (Depend variable: Aflatoxin samples >20ppb)

Contrast: Aflatoxin samples >20ppb	DF	Contrast SS	Mean Square	F Value	Pr > F
1 vs. 2	1	0.30000000	0.30000000	2.36	0.1318
1 vs. 3	1	0.53333333	0.53333333	4.20	0.0467
2 vs. 3	1	0.03333333	0.03333333	0.26	0.6111
1 vs. 2 & 3	1	0.54444444	0.54444444	4.29	0.0446

Yellow highlighted are contrasts for which with significant differences are detected (at P>r <0.0001). Contrast 1 = harvest, Contrast 2 = 4 weeks post-harvest, Contrast 3 = 8 weeks post-harvest.

Given all the results from the time-course development study, it can clearly be said that aflatoxin contamination significantly increases between four and eight weeks after harvest. Like aflatoxin content, the incidence of damaged pods also increases during this period. While insect damage significantly decreases during storage, the incidence of broken (likely caused by handling or insect damage) pods significantly increases. The incidence of moldy/discolored pods 8 weeks post-harvest also shows an inclining trend, however, not significantly in this study. That said, it has to be noted that aflatoxin contamination can precede the visible onset of mold infestation and that the significant increase in aflatoxins over time proves the presence of aflatoxin-producing fungi in damaged pods even without the appearance of mold.

Cost implications and economic value of sorting out damaged nuts

The presence of aflatoxin often correlates with damaged pods in peanut production. Breaks in the pod allow aspergillus to enter, and when moisture levels are high, it thrives, resulting in aflatoxin contamination.

Methods used elsewhere that have achieved a good degree of success with regard to reducing the level of aflatoxin experienced include removing all damaged pods and or all discolored peanuts. In India, removing just the damaged pods significantly reduces the aflatoxin level in the nuts coming out of good pods. In Malawi, removing all discolored/shriveled and damaged nuts significantly reduces aflatoxin levels in the remaining nuts. Nevertheless, both processes have economic costs.

Given this years' conditions, the probability of a buyer purchasing aflatoxin contaminated peanuts was high. However the cost of improving the quality and reducing the risk of aflatoxin needs to be calculated and considered.

Scenario: Remove all damaged pods and discolored nuts from the good pods.

- On average during Phase 2, 12.15% of pods were damaged.
- On average at Phase 2, 7.95% of the good shelled nuts were damaged.
- Traders buy 50kg bags
- The price for peanuts during Phase 2 was $0.51/kg

- Approximately 50% of the nuts in damaged pods were damaged, and there is a strong likelihood that a good nut next to a bad nut could have aflatoxin contamination. Therefore, to be safe, until there is evidence proving that good nuts from bad pods are 'clean' they should be discarded.
- Aflatoxin was not only found in nuts from damaged pods; it was also found in nuts from what appeared to be undamaged pods. Therefore, making an assumption that these are the discolored nuts in the good samples, they may need to be removed as well.
- It is possible that some value may still be found selling blemished nuts but for the purpose of this analysis we will assume there is none.

Since traders buy 50kg bags, and since one cannot simply deduct 12.15% (6.08kg), that 6.08kg needs to be replaced with 'good nuts' from undamaged pods – To get to 6.08kgs, the farmer would have to remove 738g of damaged nuts, and that 740g would have had another 90g removed. Therefore, to get 50kg of 'good' nuts from undamaged pods you will have to have sorted through 56.9kg of shelled nuts.

The value of Fair Average Quality (i.e. the generally accepted quality bought by traders) nuts in the market in Phase 2 was $25.81 per 50kg sack (1,600MZN/50kg bag of 32 MZN/kg), the minimum value of unblemished nuts in Phase 2 would have been $29.37/50kg (1,821MZN/50kg bag or 36 MZN/kg).[3]

However, on average 7.95% of the nuts coming from the good pods were also discolored and damaged. Thus, in order to purchase 50kg of unblemished nuts, the farmer would need to remove (and add) a further 4.3kg of good nuts. Therefore, the total weight of nuts needed to produce a 50kg sack of unblemished nuts is 61.2kg at a cost of $31.58 (1,958 MZN/50kg bag or 39 MZN/kg).

Without compensating for labor the minimum premium just to cover the costs of throwing away damaged pods and discolored nuts would need to be $1/MT or $5.78/50 kg sack or 7 MZN/kg.

HELVETAS is in discussion with PAKKA AG, who specializes in the trading of organic and fair trade certified cashew nuts, peanuts and other nuts. They are currently willing to offer a quality premium of 2 MZN per kg and 5 MZN/kg for organic product and would sell the products into the fair trade certified markets of Europe which have particularly stringent requirements around aflatoxin. PAKKA AG faces considerable risks buying ground nuts from this area if the same levels of aflatoxin prevalence occur every year. If PAKKA AG's quality requirements are to deliver into the European markets they will need to significantly reduce their aflatoxin risk. If they choose to implement this by requesting the removal of all discolored pods and puts, the premium PAKKA AG is offering for quality does not adequately compensate farmers for the removed product and the additional labor that they would have to provide to remove the damaged pods and damaged peanuts given the current levels of damaged and discolored pods and the pricing structure. Even when the premium for organic products is added to the end price, it is not sufficient to cover the costs of the removed product and the additional labor incurred by the farmers. Furthermore, there is the risk that farmers will shell the damaged pods and include what appears to be good nuts in the sacks for sale since they cannot see the aflatoxin risk. (Given half the damage at harvest to the pods was through insects which must have been in the soil, organic farming would prevent chemical treatments to reduce insect damage which again increases the risk of aflatoxin in damaged pods.)

[3] Calculations use an exchange rate of 62 MZN to 1 USD.

Table 14: Possible cost implications of removing all nuts from damaged pods, and additionally all damaged nuts

	Current Price Structure	Cost of Improved Quality	Farmer 1: Quality nuts sold to PAKKA AG	Farmer 2: Quality Organic nuts sold to PAKKA AG
1 Bag	50kg	**50kg**	50kg	50kg
Additional quantity needed (12.15% damaged pods)		**+6.9kg**	+6.9kg	+6.9kg
Additional quantity needed for additional damaged nuts not from damaged pods (7.95% damaged nuts)		**+4.3kg**	+4.3kg	+4.3kg
Premium needed (12.15% damaged pods)		**+$3.56**		
Premium needed (7.95% damaged nuts)		**+$2.21**		
PAKKA AG Quality Premium (2MZN/kg)			+$1.61	+$1.61
PAKKA AG Organic Premium (5MZN/kg)				+$5.65
TOTAL Farmer would receive	$25.81	**$31.58**	$27.42	$33.07

ANNEX A. HELVETAS PEANUT FARMER SURVEY RESULTS

General information	
15	Farmers participated. 9 were from Erati District & 6 were from Meconta District.[4]
11	Male farmers participated
4	Female farmers participated
100% (15)	Report that rainfall is their main source of water for peanut production
Post-harvest information	
93% (14)	Dry uprooted plants and pods in numerous piles, randomly allocated in the field[5]
14 days	Was the average amount of time that farmers dried in this way (median = 15.6 days)
93% (14)	Of farmers dried peanut pods on the ground (no tarpaulin)
13% (2)	Of farmers dried their uprooted peanut plant with the pods in a secure location
80% (12)	Of farmers then remove the pod and dry the shell on the ground[6] in a secured location, e.g. inside house
2	Farmers indicated that they also use a "dryer type A" to dry their peanut pods.[7]
86% (13)	Of farmers clean and sort their peanut pods, removing damaged and diseased pods, especially those with insect damage.
80% (12)	Had finished drying their peanut pods as of 24 May 2019, which was later than anticipated due to the cyclones
40% (6)	Of farmers indicated that they normally shell their peanut pods immediately after drying them in the shell
	The remaining farmers indicate that they leave their peanut pods in the shell for an average of 10.7 days (median = 7 days)[8]
10	Farmers indicate that they store their dried peanut pods in their house in a bag or traditional silo
	No farmer does anything else to their peanut pods to prepare them for shelling
0	Farmers dry their peanuts again after shelling them
73% (11)	Of farmers were <u>not</u> able to dry their peanut pods in the shell and store them before Tropical Cyclone Kenneth hit[9]
80% (12)	Of farmers will not try to dry their peanuts again

[4] See map in Annex D.
[5] No farmers dry peanuts in one heap; 1 farmer dries uprooted peanut plant and pod in field in piles along the row.
[6] 2 farmers responded that they dried on the ground in a secured location on "plastic"; 1 farmer on a traditional mat; and 1 farmer dried theirs on the roof on a traditional mat.
[7] See Annex E for a visual of Dryer A.
[8] Of the 4 farmers who responded, they will leave their peanuts in the shell for 3.3 days if consuming themselves versus 4.8 days if they are planning to sell them.
[9] These 11 farmers attempted to dry their peanuts in the house and/or dried for longer in the field once the weather improved.

7 days	Is the usual length of time farmers keep their peanuts in storage before shelling them (5 out of 8 respondents)[10]
	Farmers waited to shell for 1 day (5 out of 9 respondents) or 7 days (4) if consuming peanuts themselves and 7 days if selling (5).[11]
87% (13)	Farmers indicate that they have **shelled** peanut in storage as of 24 May 2019.
	4 farmers say they have stored their **shelled** peanuts for 4 to 13 days; 4 have stored for 12 to 14 days; 5 have stored for 30 to 60 days.[12]
80% (12)	Of farmers note that Cyclone Kenneth impacted their peanut harvest through high moisture and germination
80% (12)	Of farmers state that they had to dry their peanuts for longer than usual, approximately 13.8 days on average (median = 18 days)
67% (10)	Of farmers indicate that they will not be able to sell them for the same price due to bad quality and damaged pods.

[10] The other 3 farmers who answered store their peanuts for 16, 90, and 120 days.
[11] The other 4 farmers who answered store the peanuts they sell for 10, 14, 60, and 120 days.
[12] Of the 7 farmers who responded, 4 indicate that they plan to shell their peanuts in an additional 150 days; 1 in 60 days; the remaining 2 in 3 days and 5 days.

ANNEX B. TESTING RESULTS – ALL PHASES

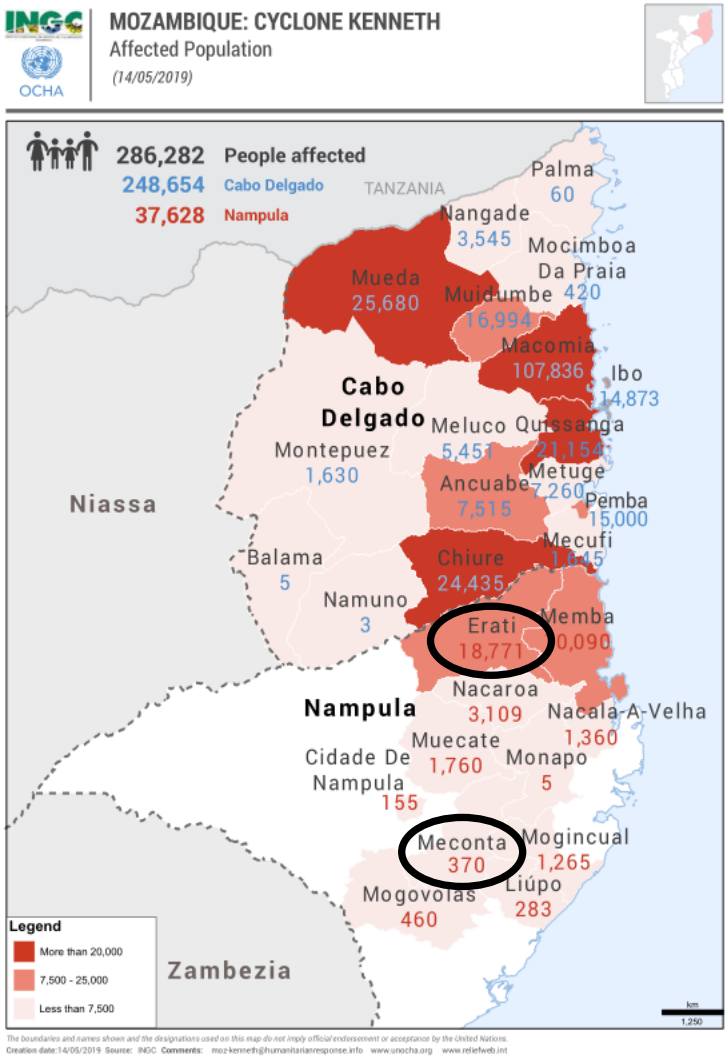
	1st Stage Harvest	2nd Stage Drying	3rd Stage Storage
	March 2019	April 2019	June 2019
Avg. Moisture of Stored Peanuts			
Erati (9)	50.53%	6.63%	5.33%
Meconta (6)	49.35%	6.55%	5.83%
Avg. Temperature (C) of Stored Peanuts			
Erati (9)	27.04	25.37	24.36
Meconta (6)	28.05	24.87	24.60

ANNEX C: GENERAL RESULTS - ALL FARMERS, ALL DISTRICTS

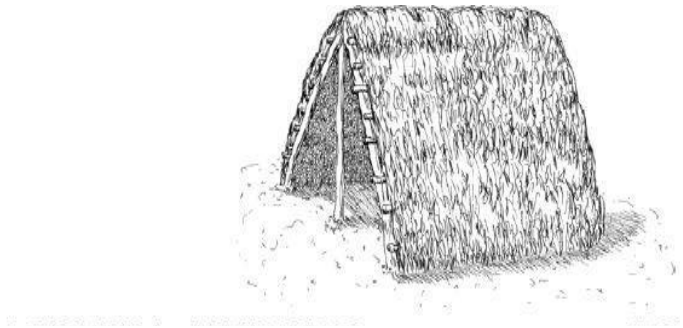
Province	District	Aflatoxin (ppb)	% Pods with damage in sample	% Pods with insect damage in sample	% Pods with mechanical damage in sample	% Pods with mold or discoloration	% Bad nuts found in bad pods	% Bad nuts found in good pods
Cabo Delgado	Chiure	901.2	25	2.6	3.4	18.9	51.3	13.2
Cabo Delgado	Chiure	480.6	32	11.5	1.0	19.8	63.2	12.0
Cabo Delgado	Chiure	133.8	19	9.9	0.7	8.5	35.6	23.3
Cabo Delgado	Chiure	130.8	18	6.2	9.4	1.9	6.4	8.5
Cabo Delgado	Chiure	0.78	23	10.5	9.1	3.5	35.2	4.8
Cabo Delgado	Chiure	45.7	8	2.5	0.5	5.4	26.7	5.0
Cabo Delgado	Chiure	40.7	13	4.5	2.6	6.1	67.3	3.5
Cabo Delgado	Chiure	27.1	20	15.4	0.2	4.8	2.2	6.1
Cabo Delgado	Chiure	9.6	16	9.9	1.5	4.4	53.0	6.7
Cabo Delgado	Chiure	1.6	16	3.9	2.6	9.8	34.0	2.4
Cabo Delgado	Chiure	1.6	6	2.2	1.5	2.4	39.0	1.1
Cabo Delgado	Chiure	1.4	26	8.8	2.1	15.2	6.1	0.8
Cabo Delgado	Chiure	1.3	10	5.9	1.0	3.4	48.8	4.4
Cabo Delgado	Chiure	1.3	17	1.5	1.1	14.2	31.6	4.8
Cabo Delgado	Chiure	1.2	10	5.2	0.9	3.9	35.7	9.6
Nampula	Erati	370.2	8	1.3	1.8	4.6	17.4	2.4
Nampula	Erati	240.6	16	1.4	0.3	14.4	27.9	3.0
Nampula	Erati	106.8	14	6.5	2.3	5.6	42.1	4.2
Nampula	Erati	0.59	9	1.8	0.5	6.4	16.6	2.0
Nampula	Erati	26.3	20	3.1	0.2	17.2	25.9	3.4
Nampula	Erati	18.9	12	3.7	2.6	5.9	34.9	13.6
Nampula	Erati	14.5	7	1.8	0.0	5.6	25.0	8.3
Nampula	Erati	5.3	8	2.3	1.4	4.5	39.4	2.3
Nampula	Erati	1.5	22	10.5	3.1	8.6	45.1	10.8
Nampula	Erati	1.4	16	6.5	4.5	5.1	57.3	6.4
Nampula	Erati	0.5	25	2.4	1.9	20.3	40.0	1.8
Nampula	Erati	1.4	5	1.4	0.4	3.2	25.4	3.0
Nampula	Erati	1.2	2	0.3	0.2	1.7	38.6	0.1
Nampula	Erati	1.1	7	1.9	1.8	3.0	38.7	7.4
Nampula	Erati	1.1	7	1.2	0.7	5.0	19.5	1.9
Nampula	Meconta	445.2	11	0.7	1.7	8.4	33.9	2.5
Nampula	Meconta	345.2	13	2.8	5.5	4.8	40.5	5.0
Nampula	Meconta	50.7	12	1.6	2.9	7.1	50.0	3.3
Nampula	Meconta	42.2	12	0.8	6.3	4.4	39.4	9.0
Nampula	Meconta	16.6	7	0.5	2.3	3.7	27.3	2.8
Nampula	Meconta	12.8	14	6.4	4.0	3.5	38.7	2.2
Nampula	Meconta	1.8	7	1.4	1.1	4.9	14.5	2.6

Nampula	Meconta	1.6	7	1.8	1.8	3.8	33.0	4.8
Nampula	Meconta	1.5	9	4.5	1.1	3.0	25.8	24.0
Nampula	Meconta	1.5	4	2.2	0.8	1.3	56.9	95.1
Nampula	Meconta	2.3	20	4.9	0.7	13.9	35.3	2.1
Nampula	Meconta	4	9	1.8	1.3	6.1	27.3	2.6
Nampula	Meconta	1.3	7	1.0	1.6	4.7	23.4	4.0
Nampula	Meconta	1.2	5	0.8	0.5	3.4	13.4	3.7
Nampula	Meconta	1.2	15	0.7	4.1	10.5	25.3	1.7
Nampula	Mogovola	471.3	9	2.5	2.6	3.9	37.7	3.7
Nampula	Mogovola	175.1	14	1.3	1.4	11.7	22.4	1.7
Nampula	Mogovola	163.2	14	4.2	1.4	8.3	56.5	4.8
Nampula	Mogovola	0.96	10	1.5	1.3	7.1	30.0	2.8
Nampula	Mogovola	0.91	7	0.6	0.9	5.2	22.2	1.4
Nampula	Mogovola	0.87	8	2.3	2.2	3.9	27.3	1.8
Nampula	Mogovola	0.72	11	3.3	2.8	4.7	42.4	3.7
Nampula	Mogovola	0.58	6	1.9	1.3	3.1	33.3	1.5
Nampula	Mogovola	41.7	11	3.6	2.2	5.3	69.5	3.6
Nampula	Mogovola	1.8	5	1.8	0.6	2.8	55.7	1.4
Nampula	Mogovola	1.4	10	2.8	1.3	5.7	29.4	4.2
Nampula	Mogovola	1.3	7	1.7	1.5	3.6	38.3	96.4
Nampula	Mogovola	1.1	6	1.0	0.9	3.9	24.2	1.6
Nampula	Mogovola	2	12	0.9	1.5	9.4	26.2	3.6
Nampula	Mogovola	1	13	2.9	2.2	8.3	33.6	3.1

ANNEX D: CYCLONE KENNETH AFFECTED AREAS



ANNEX E: EXAMPLE OF DRYER TYPE “A”



ANNEX F: SORTING PROTOCOL